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# THE JOURNAL

OF

## THE LINNEAN SOCIETY OF LONDON

### (BOTANY)

The Herbal of Valerius Cordus. By T. A. SPRAGUE, D.Sc., F.L.S., Deputy Keeper of the Herbarium and Library, Royal Botanic Gardens, Kew, and M. S. SPRAGUE, M.A.

[Read 6 May 1937]

#### I. SCOPE AND CHARACTERISTICS OF THE HERBAL.

The 'Historia Plantarum' of Valerius Cordus—written before 1545, but not printed until 1561—is the most important of the early German herbals of the sixteenth century. The chief value of those of Brunfels (1530) and Fuchs (1542) lies in their fine wood engravings, executed by draughtsmen of repute. Bock (1539), on the other hand, led the way in supplying short original descriptions, in German, of the herbs with which he dealt. Valerius Cordus, who wrote in Latin, far surpassed Bock in the exactness and detailed nature of his descriptions, and may be regarded as the real founder of modern phytography. His 'Historia Plantarum' includes not only medicinal plants wild or cultivated in Germany and Italy, but numerous foreign woods, barks, fruits, roots, and resins imported into Germany in the sixteenth century. Thus it has a much wider scope than the herbals of Brunfels, Bock, and Fuchs, containing early records of various exotic drugs and timbers, in addition to numerous first records of German and Italian plants. In this respect Valerius Cordus was the forerunner of Clusius.

About 66 'new' plants appear to have been published in the 'Historia' out of a total of over 500 described or figured in that work. These are marked by an asterisk in the Conspectus (pp. 11–18) and Enumeration (pp. 19–104). Among the more outstanding were *Matteucia Struthiopteris* (Ostrich Fern), *Butomus umbellatus*, *Chenopodium Vulvaria*, *Dentaria bulbifera* and *D. enneaphylos*, *Saxifraga Aizoon*, *Euphorbia dulcis* var. *lasiocarpa*, *Pimpinella nigra*.

*Oxycoccus quadripetalus*, and *Scorzonera humilis*. *Menyanthes trifoliata*, *Ledum palustre* and *Lathraea Squamaria*, though mentioned in certain mediaeval manuscripts, were discovered independently by Valerius Cordus. Among the first records of drugs were *Languas officinarum* (Lesser Galangale) and *Anomum Korarima*, an Abyssinian species of *Aframomum* still known only from its fruits. The identification of *Presilium citrinum* V. Cord. with *Chlorophora tinctoria* (Fustic) shows that that important tropical American dye-wood was known and used in Europe a century earlier than hitherto supposed.

New plants added by Gesner in an Appendix to the fourth book of the 'Historia' included the species now known as *Tulipa Gesneriana*, *Cotoneaster integerrimus*, *Chamaenerium Dodonaei*, and *Lonicera alpigena*.

That the 'Historia' deals mainly with medicinal plants is not immediately obvious from inspection. Unlike Brunfels and Fuchs, Valerius Cordus did not deal with the therapeutic application of the plants described by him, though as a pharmacognosist he mentioned characteristic properties, such as taste and smell, by which they might be recognized. Information regarding their medicinal uses may be obtained from the references to Rosenthal (1862), Dragendorff (1898), Potter's 'Cyclopaedia' (1915), and Leclerc (1922), supplied throughout the Enumeration (pp. 19-104). A list by Cordus of the principal localities in Germany which he found to be rich in medicinal plants appeared in the same volume as the 'Historia'.

The 'Historia' forms a land-mark in descriptive botany. This was recognized by Tournefort (1700, p. 26), who named Valerius Cordus as the first to excel in plant description; and by Haller (1771, 1, p. 282), who wrote that he was the first to show how to describe plants from nature, instead of relying on the accounts of the ancients. The description of *Tithymallus pentactonius* V. Cord. may be taken as a good example of his method. He starts by describing the mode of origin and nature of the above-ground stems, the arrangement and measurements of the leaves, the whorl of five other leaves at the apex of the stem, and the branching of the inflorescence. Then follows a mention of the cyathia (*eruptiones*) and a detailed description of the capsule and seeds. The presence of supernumerary branches below the pentachasium is then noted. Finally, there come an account of the horizontal rhizomes and their adventitious roots, and a note that the whole herb is full of a milky juice. The habitat, 'in shrubby places', is appended. The description is sufficiently detailed to identify the plant with certainty as *Euphorbia dulcis* var. *lasiocarpa*. Similarly, the relatively short description of *Ixopus* indicates *Scorzonera humilis* beyond a shadow of doubt.

E. L. Greene (1909, pp. 280-94) gives the impression, gained from a superficial examination of the 'Historia', that Cordus had paid considerable attention to morphology. Actually, Cordus was a keen observer, who described the parts of plants in empirical language, paying more attention to their function than to their morphological nature; thus he described the rhizome

of *Euphorbia dulcis* var. *lasiocarpa* as a root, but pointed out that its function was not absorption, but the production of young shoots (*asparagi*) from which are developed the erect stems of the following year; and he gave the name 'fibres' to the adventitious roots, while recognizing that their function was to draw nourishment from the ground. Unfortunately, many of the statements in Greene's delightful account of Valerius Cordus are misleading. Two examples may be given: *coliculus* (*cauliculus*) was not a new term invented by Cordus, but an old one used by Pliny and Ruellius; and only one of the first four types described by Cordus was new to science, the three others, *Gratiola officinalis*, *Sagittaria sagittifolia*, and *Polygonum Bistorta*, being known in the Middle Ages.

An account of the terminology employed in the 'Historia' is being prepared and will be published separately, as its inclusion here is precluded by considerations of space. Only after the appearance of a glossary will it be possible to give an adequate account of the morphological concepts held by Cordus.

## 2. LIFE OF VALERIUS CORDUS.

Valerius Cordus was born on 18 February 1515 at Simtshausen\* in Hesse, a village lying between Marburg and Frankenberg. He was carefully educated by his father, Euricius Cordus, the author of the 'Botanologicon' (1534), who inspired his son with his own love of science, more especially of botany. Valerius graduated as Baccalaureus in medicine at Marburg at the age of sixteen, and afterwards went on to Wittenberg, where he apparently spent a considerable time. Whereas Euricius Cordus seems to have been soured and embittered by his experience of life, Valerius possessed a happy disposition and a real genius for friendship. At Wittenberg older men, such as Melanchthon, regarded him with affection and esteem, while friends of his own age, chief among whom were Crato von Kraftheim, Georg Ömler†, and Hieronymus Schreiber, were devoted to him. Of these three, Crato wrote a brief account of Cordus, which was printed in Gesner's volume, published in 1561; to Ömler, who is better known as Acmylius of Stolberg, Cordus entrusted his manuscripts before his departure for Italy, while Schreiber accompanied him there, and wrote a long and detailed account of his illness and death.

The years between 1531 and 1543, when Cordus left Germany on that journey to Italy from which he never returned, were spent partly in long journeys on foot through the Erzgebirge, the Thüringerwald and the Harz, in search of plants and minerals, and in visits to Tübingen and other places. Tschirch says that Cordus made his way north as far as Scandinavia, but of this there seems to be no clear evidence. Cordus also spent some months in Leipzig, with his uncle, Joachim Johannes Ralla, the apothecary. Here he worked in the Salomonis-apotheke, and distilled many essential oils. It may very

\* August Schulz (1916, 38) gives his birthplace as Erfurt.

† Vide Irmisch, 1862, 34-39.



probably have been at this time that he wrote his 'Dispensatorium', which he put together at the request of Ralla. According to one account, Ralla brought it to the notice of the municipal authorities of Nuremberg, and had it printed in 1535. Haller (1771, I, p. 282) cites an octavo edition published at Nuremberg in 1535, but according to Peters (1891, pp. 185 et seq.) the first edition did not appear till 1546. At Wittenberg, which seems to have been his headquarters, Cordus devoted himself to the study of medicine, pharmacy, and pharmacognosy, and lectured there three times on Dioscorides. Crato tells us that in 1539 he and Cordus were present at a lecture on Nicander by Melanchthon.

In 1543 Cordus and Schreiber travelled to Italy, where they stayed some time in Padua, Pavia, Ferrara, and Bologna. Then with two friends and a servant Cordus set out for Rome, passing through Florence, Pisa, Lucca, and Livorno. As Cordus had read in Pliny, or learnt elsewhere, that those districts were rich in simples, they did not go the most direct way, but travelled in the heat of summer, partly on horseback, partly on foot, through almost trackless mountain regions, marshy plains, and arid stretches of coast. The whole party paid for their daring by attacks of fever. Cordus, moreover, while leading his horse out of the stable, received a kick on the leg from another horse. No bones were broken and no wound was caused, for his riding-boot had protected him to some extent. Cordus, however, felt pain, but, in spite of the remonstrances of his companions, he took no notice of it, and continued his journey. That day their way lay along steep tracks, made slippery by rain, and, fearing lest the horses should fall, they went a considerable distance on foot. Thus Cordus's leg, already injured by the kick, became inflamed, and fever set in. This weakened him so much that he had very great difficulty in reaching Rome, although it was only two or three days' journey distant. Four or five days later, Schreiber arrived, and found Cordus seriously ill; a doctor was sent for, under whose care Cordus began to improve, till he seemed to be on the high road to recovery. Schreiber thought that he could now safely leave his friend, and accordingly set off for Naples, where he had business to transact, hoping to find Cordus convalescent on his return. Cordus, however, had a relapse, and died on 25 September 1544. Permission to bury him was obtained only with great difficulty. In Rome at that time all the doctors were bound by oath not to attend any person dangerously ill more than twice or thrice unless the sick man made his confession and received Holy Communion. Cordus was told of this, and sent for a German priest, made his confession, asked for absolution, and enquired whether it would be possible for him to receive Communion in both kinds. The priest asserted solemnly that it was not in his power to do this; if he did allow it, imprisonment and the stake would be his fate. Cordus, hearing this, acquiesced, recalling to mind the saying 'Crede et manducasti', and the priest departed, telling those who were present that the sick man had made his confession duly, but that he (the priest) feared that because of his extreme illness he could not swallow

the Host. Cordus's friends now heard that the matter had been reported to certain 'Penitentiary Monks', who threatened to throw the corpse into the Tiber, unless the sick man received Holy Communion before his death. Cordus's friends kept things quiet as far as they could, and Cordus himself, suspecting how matters stood, scarcely spoke to anyone. At length, when he was at the point of death, in order to satisfy the monks as far as possible, they sent hastily for a priest to give him Extreme Unction, and thus secured burial for the corpse and safety for themselves. Cordus was buried in the German church, Santa Maria dell' Anima.

For further details concerning the life of Valerius Cordus, reference may be made to August Schulz (1916) and the works therein cited (p. 37, footnote 1).

### 3. PUBLICATION OF THE HERBAL.

Cordus himself published none of his works, though he prepared his 'Dispensatorium' for the press (Peters, 1883, p. 68). This was issued in 1546 under the auspices of the Nuremberg Town Council. His 'Annotationes in Pedacii Dioscoridis Anazarbei de medica materia libros V' first appeared as an appendix to the 1549 edition of Walther Ryff's Dioscorides. A second edition of the 'Annotationes' was printed in 1561 in an 'omnibus' volume edited by Gesner, and including also the 'Historiæ Plantarum, libri IV', 'Sylva observationum variarum', and two pharmaceutical works, all by Cordus, in addition to Aretius, 'Stock-hornii et Nessi montium descriptio' and Gesner's own 'Horti Germaniac'. The fifth book of the 'Historia', prepared by Cordus himself, was published by Gesner as an independent work in 1563, and was reprinted in 1751 in Schmidel's edition of Gesner's 'Opera'. Thalius (1588, p. 37) mentions having seen the manuscript of an unpublished sixth book of the 'Historia' in the possession of Ömler, some of the chapters of which had been inserted in the fourth book. Among the species described in it was *Caucalis daucoides* Linn., according to identifications by Thalius (loc. cit.) and Schulze (1905, p. 14).

Gesner's 'omnibus' volume is a small folio of 317 leaves, composed of the following elements:—

1. Prefatory letter from Conrad Gesner to the College of Physicians in the University of Wittenberg (fol. a2, a3 r.).
2. Letter from Gesner to the son of Johannes Ralla, to whose memory Gesner dedicates the 'Annotationes' (fol. a3 v., a4 r.).
3. Preface to the 'Annotationes', followed by a list of commentators on Dioscorides (fol. a4 r.–b v.).
4. Letter from Johannes Crato to Gesner, dated 1559 (fol. b2, b3 r.).
5. Extract from a letter from Ge. Agricola to Wolfgang Meurer (fol. b3 v.).
6. Extract from Walther Ryff's preface to the first edition of the 'Annotationes' (fol. b3 v.).
7. Extract from Gesner's Bibliotheca, concerning Euricius Cordus (fol. b3 v.).

8. Encomium of Valerius Cordus and Johannes Ralla by Andreas Ellinger (fol. b4 r.).

9. 'Valerii Cordi Simesusii, in Pedacii Dioscoridis Anazarbei de medica materia libros V, Annotationes' (fol. 1-84).

10. Letter from Gesner to Hieronymus Herold, dealing with the preparation of the 'Historia' for press (fol. 85).

11. 'Valerii Cordi Simesusii, Historiae plantarum, libri IV':

'Liber I, qui est de herbis diversis' (fol. 86-119 r.).

'Liber II, quo illas praecipue persequitur, quarum historia a veteribus vel exacte tradita non est, vel omnino practerita' (fol. 119 v.-173).

'Liber III, arborum, fructuum, et arbustorum descriptiones continens' (fol. 174-190).

'Liber IV, in quo lignorum, corticum, et fructuum peregrinorum: item peregrinarum radicum et lachrymarum descriptiones habentur' (fol. 191-212 r.).

12. Appendix to the 'Historia' written by Gesner, containing figures and descriptions of five additional plants from Gesner's own collection of drawings (fol. 213-216).

13. 'Sylva observationum variarum Valerii Cordi, quas inter peregrinandum brevissime notavit, primum de rebus fossilibus, ut lepidibus, metallis, etc. deinde etiam plantis', prefaced by a letter from Gesner to Johannes Placotomus (fol. 217-224 r.).

14. 'Loca medicaminum feracia in Germania' (fol. 224 v.).

15. 'Valerii Cordi de artificiosis extractionibus Liber', with a prefatory letter from Gesner to Philippus Bechius (fol. 225-229 r.).

Pars I. De extractione efficaciorum partium e medicamentis purgantibus, simplicibus et compositis.

Pars II. De destillatione oleorum.

Pars III. De destillatione olei e Chalcantho duplicis, eorumque viribus.

16. 'Valerii Cordi compositiones medicinales aliquot, non vulgares', with a prefatory letter from Gesner to Sebaldus Hauuenreuter (fol. 229 v.-231).

17. 'Stoec-hornii et Nessi in Bernatium Helvetiorum dititione montium, et nascentium in eis stirpium brevis descriptio, a Benedicto Aretio Graecae et Hebraicae linguarum in schola Bernensi professore clarissimo dictata', with a prefatory letter from Gesner to Christophorus Piperinus (fol. 232-235).

18. 'Horti Germaniae, authore Conrado Gesnero', with a prefatory letter from Gesner to Stephanus Lauraeus (fol. 236-288 r.).

19. 'Conradi Gesneri Appendix libri sui de Hortis Germaniae', with a prefatory letter from Gesner to Franciscus Calceolarius (fol. 288 r.-298 r.).

20. 'Conrad. Gesnerus ad lectorem, de quibusdam vel emendandis, vel addendis in suo De hortis Germaniae libro' (fol. 298 v.-300 r.).

21. 'Emendanda quaedam in Val. Cordi libris' (fol. 300 r.-301 r.).

22. 'Gamelion Michaelis Barth Annaebergensis ad M. Mauricium Steinmetz sponsum amicum s.s. de sponsa eius Virgine honestiss. Catharina filia opt. viri Ioann. Rallae pharmacopoli et civis Lipsici' (fol. 301 v., 302 r.).
23. Registrum and imprint (fol. 302 v.).
24. 'In Valerii Cordi Annotationes index' (fol. AA1-AA3 v.).
25. 'Index in IIII. libros de Stirpibus Val. Cor.' (fol. AA3 v.-AA5 r.).
26. 'Index in Valerii Cordi Sylvam observationum' (fol. AA5 v.-AA6 r.).

The most valuable element in the volume is undoubtedly the 'Historiae plantarum libri IV' of Valerius Cordus (item 11), which, together with liber V, published separately, forms the subject of the present paper. His 'Annotationes' (item 9) is a commentary on Dioscorides, and his 'Sylva' (item 13) is a collection of miscellaneous observations on minerals, plants, and animals. These have been studied by us only in so far as they throw light on the identifications of plants in the 'Historia Plantarum'.

The manuscript of the 'Annotationes' used by Ryff (1549) is stated by Crato (1561, fol. b2 r.) to have been the notebook of a student who had attended the first course of lectures by Cordus on Dioscorides: 'Dioscoridem in Schola Vuitebergensi ter legit, ac primo ea quidem dictavit, quae nescio quomodo extant'. Gesner (1561, fol. a4 r.), however, had at his disposal a copy of the 'Annotationes', corrected by Cordus himself from the beginning of the work up to and including Liber II, Caput VIII (de Hordeo). For this he was indebted to Johannes Placotomus, a physician of Danzig (Gesner, 1561, 217 r.). This corrected copy is mentioned also by Crato (loc. cit.): 'Pervagatus deinde Thuringiam atque vicina loca, multa mutavit et alios quasi Commentarios in Dioscoridem confecit. Atque hos postremos arbitror ad tuas manus pervenisse'.

For the 'Historiae plantarum, libri III' Gesner (1561, 85 r.) had two documents, one being the original manuscript of Valerius Cordus, written about 1540, and containing annotations by Ömler, in whose possession it had formerly been. Gesner received this from Johannes Placotomus (Gesner, 1561, 217 r.). The second document was a fair copy, also annotated, communicated by Hieronymus Herold, a physician of Nuremberg. In Ömler's annotations the name Cordus was abbreviated, the first three letters 'Cor' being replaced by a symbol representing a conventional heart. This was taken for an 'O' by the printer, and hence the name Cordus occurs as 'Odus' ('Odi' in the genitive) in several places in the printed work, e.g. in the note following the description of *Scorodonia* V. Cord., Hist. 91 v.: 'Hindtleube. Est scordium Montanum Odi' (vide Thalius, 1588, p. 111). The 'Sylva observationum variarum' was printed from a manuscript also received from Placotomus by Gesner (1561, 217 r.): 'et haec observationes rerum naturae variarum, pro summo et benignissimo candore tuo, mittere ad me non dedignatus es, et ut publicae utilitatis ergo evulgarentur, hortatus'.

The original manuscript of the fifth book of the 'Historia', published under the title 'Stirpium descriptionis liber quintus, qua in Italia sibi visas describit' was lent to Gesner by Prof. Wolfgang Meurer of Leipzig, to whom he returned it after the work was printed (Gesner, 1751, p. 3).

The wood engravings in the 'Historia' were added by Gesner: an unillustrated herbal would at that date (1561) have had a very small sale. Most of them were printed from the wood blocks used in the Latin edition of Bock's herbal, printed in 1552 by Vuendelinus Rihelius, the father of Josias Rihelius, the publisher of the 'Historia'. Some of the illustrations were adapted from figures in the works of contemporary authors, e.g. Dodoens and Mattioli, others were reproduced from drawings in Gesner's own collection, and yet others from drawings sent to Gesner by Johannes Kentmann of Torgau.

#### 4. PREVIOUS IDENTIFICATIONS OF THE PLANTS DESCRIBED AND FIGURED.

Georg Ömler (Aemylius) supplied the German names of a few plants described in the 'Historia', and mentioned other Latin names used by Cordus, but his notes cannot in most cases be distinguished from those of the other (unknown) annotator or those of Gesner himself. Where the abbreviation 'Odus' (vide supra) occurs, however, we may assume that we are dealing with one of Ömler's footnotes, since Gesner himself spelt the name Cordus in full. Notes by Ömler are appended to the descriptions of *Scorodonia* (no. 15\*), *Trifolium palustre* (no. 31), *Sisyrinchion* (no. 129), and *Polygalon* (no. 131 A).

The footnote to *Polygalon* reads: '*Glycyrrhiza sylvestris*, convenit enim glycyrrhizae sapore radice'. According to Thalius (1588, p. 88), this was written by Ömler: '*Polygalon Cordi*, Foenugraeci sylvestris nomine habitum a Trago: Aemylius Glycyrrhizam sylvestrem, ob dulcem saporem nominabat, ut in Scholio, quod descriptioni apud Cordum subiectum est, patet: illud enim Aemylii est. Verum alia Glycyrrhiza sylvestris nostra, de qua supra'.

Thalius (loc. cit. p. 116) was, however, apparently mistaken in stating that Ömler had added the figure of *Selaginis species altera* (no. 80 B, *Lycopodium clavatum*) to the description of *Chamaepeuce* Cord. (no. 80 A, *Ledum palustre*), since that figure was one of those borrowed from Bock by Gesner: '*Selaginis species altera* (sicuti eodem etiam nomine Georgius Aemilius olim herbam istam tandem censebat) Muscus nempe terrestris Tragi ac Matthioli, Lycopodium vero Dodonaei. Eius icon perperam pro Chamaepeuce aliqua ab Aemilio apud Cordum posita est, propterea quod vera Cordi Chamaepeuce tum temporis ipsi visa nondum fuisset, quam aliquot annis post, cum primum mihi notitia cum eo viro intercedere coepisset, ei ut et aliis amicis copiosam ex Nariscorum sylvis misi, cuius aliquot surculos ipse mox Gesnero paulo ante eius obitum itidem trans mittebat'.

The footnote appended to the description of *Cornus foemina* (no. 344 A, *Cornus sanguinea*) is attributed by August Schulz (1916, p. 60) to Ömler,

perhaps correctly, since the note concerns Stolberg, where Ömler lived. It presumably refers, not to *Cornus foemina* Cord., as supposed by Gesner, but to *Cornus mascula* (no. 344 B, *Cornus mas*), which is mentioned in the description, for purposes of comparison.

The first serious attempt to identify the plants described in the 'Historia' was made by Gesner, who supplied about 270 wood-cuts to the first four books, out of about 420 which might have been provided, allowing for the fact that such products as timbers and resins are unsuitable for illustration. The insertion of the figures was not done with very great care: thus a wood-cut of *Papaver somniferum* accompanies the text of *Panicum* (no. 77, *Setaria italica*); one of *Citrullus Colocynthis* is assigned to *Colocynthis turbinata* (no. 98 A, a form of *Cucurbita Pepo*) instead of to *Colocynthis fungosa et levis* (no. 111); and one of *Pulicaria vulgaris* is duplicated, being attached to *Psyllium* (no. 247 A, *Plantago indica*) as well as to *Conyza sylvestris hirsuta* (no. 271 A, *Inula hirta*). The unattached left-hand figure on fol. 133 r., taken from Dodonaeus, represents *Olsenichium* Cord. fol. 149 r. (no. 224, *Peucedanum palustre*).

Nevertheless, Gesner did good service by supplying about 220 figures correctly associated with descriptions given by Cordus. At the same time, by the erroneous insertion of over 40 other figures, he made it more difficult for subsequent workers to interpret the descriptions correctly. Whatever *Sonchus sylvestris* V. Cord. (no. 187 A) may have been, it was certainly not *Prenanthes purpurea*, as identified by Gesner, since Cordus stated that the flowers are yellow; and the description of *Stachys* (no. 212 A, *Marrubium peregrinum*) is inconsistent with *Stachys germanica*, a figure of which was supplied by Gesner.

The three species described by Cordus under the generic name *Conyza* (nos. 271 A, 272, 273 A) appear to be *Inula hirta*, *I. salicina*, and *I. Britannica*: Gesner gave figures of *Pulicaria vulgaris* and *Inula germanica* (nos. 271 B, C) for comparison with the first, failed to identify the second, and supplied a figure of *Inula Conyza* (no. 273 B) as representing the third. The example of *Pseudocrania* (no. 340 A, *Viburnum Lantana*) and *Cornus foemina* (no. 344 A, *Cornus sanguinea*) is even more striking: Gesner associated a figure of *Cornus sanguinea* (no. 340 B) with the former, and one of *Cornus mas* (no. 344 B) with the latter. Even after allowing for the great difficulties which he must have encountered in editing the 'Historia', and for the speed at which he worked, it would appear that Gesner was not skilled in identifying plants from descriptions, and that his abilities as a systematic botanist fell far short of his attainments as a classical scholar and a bibliographer.

The next commentator on the 'Historia' was Johannes Thalius of Stolberg in the Harz Mountains. In his 'Sylva Hercynia' he identified about 43 of the plants described and figured in the 'Historia', correctly in 35 cases and erroneously in the remaining eight. In two instances, however, he was misled by illustrations inserted by Gesner, who had supplied a figure of *Astragalus*

*glycyphyllos* (no. 131 B) to represent *Polygalon* V. Cord. (no. 131 A, *Lathyrus niger*) and one of *Inula Conyza* (no. 273 B) for *Conyza Helenitis* V. Cord. (no. 273 A, *Inula Britannica*).

Thalius (loc. cit. p. 8) states that his former preceptor, Laurentius Hiel, pointed out *Apium sylvaticum* (= *Chaerophyllum aureum* Linn., teste Schulze, 1905, p. 7) to him as *Daucus selinoides* V. Cord. (no. 249, *Pimpinella saxifraga* Linn.), but observes that the description given by Cordus agrees with the figure of *Pimpinella vulgaris seu minor* taken from Bock. Similarly, he correctly refers *Daucus angulosus* V. Cord. (no. 54, *Seseli Libanotis*) to his *Libanotis alba minor, seu amara* (loc. cit. pp. 37, 71). Under *Struthiopteris Cordi* (loc. cit. p. 119), Thalius has a long account of the Ostrich fern, *Matteucia Struthiopteris* (no. 307 A), and points out that the figure of *Asplenon sylvestre*, supplied by Gesner from Bock's herbal, represents a different plant.

Very many identifications of plants in the 'Historia' are contained in Caspar Bauhin's 'Pinax' (1623), which is an invaluable key to the sixteenth century herbals. Numerous citations are also given in Haller's 'Enumeratio' (1742).

Sprengel (1817, p. 273) gave only 38 identifications of plants in the 'Historia', and nine of these (24 per cent.) are erroneous. He misidentified six out of the seventeen Italian plants in his list, the most surprising example being *Iasme alba* (no. 488, *Jasminum officinale*) which he named '*Clematis Vitalba*', although Cordus had described the calyx with its linear teeth and the sweet-scented gamopetalous corolla. Obviously Sprengel cannot have read through the whole of the description.

The most extensive series of identifications hitherto given of the plants in the 'Historia' are those scattered through J. H. Dierbach's 'Beiträge zu Deutschlands Flora' (1825-33). This book contains identifications of German plants from all the early herbals, those from Valerius Cordus forming only a small proportion of the whole. He appears to have named about 265 plants from the 'Historia', which is approximately half the total number, allowing for the figures of other species added by Gesner. All things considered, he did very well, only about 33 of these identifications (12 per cent.) being incorrect. Among obvious mistakes are the citation of *Botrys* (no. 64, *Chenopodium Botrys*) under *Teucrium Botrys*, and of *Ixopus* (no. 55, *Scorzonera humilis*) as *Chondrilla juncea*.

The most recent contribution to the subject is a valuable paper by August Schulz (1916), which contains a list of 59 plants for which Cordus supplied localities in Middle Germany. Of these, Schulz appears to have named 51 correctly. He was unable to identify *Pteridion masculum* (no. 303, *Dryopteris Phegopteris*), *Pteridion foemina* (no. 306, *Dryopteris Linnaeana*), and *Ixopus* (no. 55, *Scorzonera humilis*), and the identity of *Sonchus sylvestris* (no. 187 A) is still in doubt. The remaining four species appear to be misidentified by him: they are nos. 54, 185, 234, and 250 of our Enumeration. His most interesting identification is that of *Stachys* V. Cord. (no. 212 A) as *Marrubium peregrinum*.

## 5. SYSTEMATIC CONSPECTUS OF PLANTS DESCRIBED AND FIGURED.

This conspectus is designed to serve a twofold purpose : to show at a glance what plants of particular families or genera are represented in the ' Historia ', and to indicate the various periods or dates at which they became known. Doubtful identifications are omitted.

The following abbreviations are employed to indicate previous records of plants concerned :—

A. Albertus Magnus, <i>fide</i> Meyer et Jessen (1867).	GD. Classical Greek, <i>fide</i> Dyer (1916).
AEL. Ancient Egyptian, <i>fide</i> Loret (1887).	M. Mediaeval Italian, <i>fide</i> Saccardo (1909).
AES. Ancient Egyptian, <i>fide</i> Schweinfurth (1884, 1887).	ME. Mediaeval European and Arabian, <i>fide</i> Fischer (1929).
AET. Ancient Egyptian, <i>fide</i> Tschirch (1909).	N. Nicander, <i>fide</i> Sprengel (1817).
AR. Mediaeval Arabian, <i>fide</i> Sprengel (1817).	NM. Nicolaus Myrepsus, <i>fide</i> Sprengel (1817).
ART. Mediaeval Arabian, <i>fide</i> Tschirch (1909).	OS. Ortus Sanitatis (1485).
B. Apuleius Barbarus (Bodley MS.), <i>fide</i> Gunther (1925).	P. Pliny, <i>fide</i> Sprengel (1817).
BC. Biblical, <i>fide</i> Carruthers (1899).	R. Classical Roman, <i>fide</i> Saccardo (1909).
Br. Otto Brunfels, <i>fide</i> Sprague (1928).	RD. Classical Roman, <i>fide</i> Dyer (1921).
C. Columella, <i>fide</i> Sprengel (1817).	T. Theophrastus, <i>fide</i> Hort et Dyer (1916).
Cr. Crateuas, <i>fide</i> Sprengel (1817).	Tr. Tragus (Bock), New Kreütter Buch (1539); and Stirp. Comment. (1552).
D. Dioscorides, <i>fide</i> Sprengel (1817).	V. Virgil, <i>fide</i> Sprengel (1817).
F. Leonhart Fuchs, <i>fide</i> Sprague and Nemes (1931).	* Not previously recorded with certainty.
G. Galen, <i>fide</i> Sprengel (1817).	

LYCOPODIACEAE : *Lycopodium clavatum* (Tr.).

FILICES : *Adiantum Capillus-Veneris* (T ; N ; R ; ME ; F ; Tr.) ; *Asplenium Adiantum-nigrum* (R ; ME) ; *A. Ruta-muraria* (M ; ME ; Br. ; F ; Tr.) ; *A. Trichomanes* (T ; D ; R ; ME ; Tr.) ; *Blechnum Spicant* (T ; ME ; Tr.) ; *Ceterach officinarum* (GD ; D ; R ; ME ; Tr.) ; *Dryopteris Filix-mas* (T ; R ; ME ; F ; Tr.) ; *D. Linnaeana* (D ; Tr.) ; *D. Phegopteris* \* ; *Matteucia Struthiopteris* \* ; *Ophioglossum vulgatum* (P ; ME ; F ; Tr.) ; *Osmunda regalis* (ME ; Tr.) ; *Phyllitis Scolopendrium* (T ; R ; ME ; Br. ; F ; Tr.) ; *Polypodium vulgare* (T ; R ; ME ; Br. ; F ; Tr.).

PinACEAE : *Larix decidua* (R ; ME ; F ; Tr.) ; *Tetraclinis articulata* (BC, p. 313, Thynne wood ; T ; RD ; C ; ME).

ALISMATACEAE : *Sagittaria sagittifolia* (R ; ME).

BUTOMACEAE : *Butomus umbellatus* \*.

GRAMINEAE : *Coix Lacryma-Jobi* (ME) ; *Cymbopogon Schoenanthus* (AET ; T) ; *Hordeum vulgare* var. *coeleste* (Dodoens, 1559) ; *Phalaris canariensis* (Tr. ; Anguillara, 1561) ; *Saccharum officinarum* (RD ; AR ; M ; ME) ; *Setaria italica* (T ; R ; ME ; F) ; *Sorghum bicolor* (ME ; F ; Tr.) ; *Zea Mays* (Tr., 1539 ; F).



**PALMAE** : *Areca Catechu* (AR ; ME) ; *Cocos nucifera* (ME).

**ARACEAE** : *Acorus Calamus* (T ; D ; R ; ME ; Mattioli, 1554) ; *Arum italicum* (T ; D ; R ; ME) ; *A. maculatum* (A ; ME ; Br. ; F ; Tr.) ; *Calla palustris* (ME ; F) ; *Dracunculus vulgaris* (T ; R ; ME ; Br. ; F ; Tr.).

**LILIACEAE** : *Allium Cepa* (AEL ; BC, p. 309 ; T ; R ; ME ; Br. ; F) ; *A. oleraceum* (F ; Tr.) ; *A. sativum* (AES, 1887 ; BC, p. 302 ; T ; R ; ME ; Br. ; F) ; *A. sativum* var. *controversum* \* ; *A. sativum* var. *Ophioscorodon* \* ; *A. ursinum* (ME ; Br. ; F ; Tr.) ; *A. vineale* (ME ; F ; Tr.) ; *Aloë barbadensis* (M ; ME ; F) ; *A. Perryi* \* ; *Anthericum ramosum* (ME) ; *Asparagus acutifolius* (T ; R ; Mattioli, 1554) ; *A. officinalis* var. *altilis* (C ; R ; ME ; Br. ; F ; Tr.) ; *Colchicum autumnale* (D ; R ; ME ; Br. ; F ; Tr.) ; *Dracaena Cinnabari* (Dioscorides, Pliny, and early Arabian geographers, fide I. B. Balfour, 1883). *D. Draco* (ME) ; *Gagea arvensis* \* ; *Lilium Martagon* (T ; M ; ME ; Br. ; F ; Tr.) ; *Muscari botryoides* (ME ; F ; Tr.) ; *M. comosum* (T ; R ; F ; Tr.) ; *Paris quadrifolia* (ME ; F ; Tr.) ; *Polygonatum multiflorum* (Br. ; F ; Tr.) ; *P. officinale* (M ; ME) ; *P. verticillatum* (? D ; F ; Tr.) ; *Ruscus aculeatus* (T ; R ; ME ; Mattioli, 1554) ; *Smilax China* (a Chinese drug, first known to the Portuguese in India in 1535, fide Garcia ab Horto, 1567, p. 167) ; *Tulipa Gesneriana* \* ; *Veratrum album* (T ; R ; ME ; F ; Tr.).

**DIOSCOREACEAE** : *Tamus communis* (GD ; N ; C ; D ; ME ; Mattioli, 1554).

**IRIDACEAE** : *Crocus sativus* (BC, p. 311 ; T ; R ; ME ; F ; Tr.) ; *Gladiolus palustris* (ME) ; *Iris aphylla* \* ; *I. foetidissima* (T ; OS ; F ; Tr.) ; *I. germanica* (D ; R ; ME ; Br. ; F ; Tr.) ; *I. Pseudacorus* (R ; ME ; Br. ; F ; Tr.) ; *I. sibirica* \*.

**ZINGIBERACEAE** : *Aframomum Melegueta* (ME) ; *A. sp.* (*Amomum Korarima*) \* ; *Curcuma domestica* (Dioscorides : altera cyperi species, i. 4 ; AR ; ME) ; *C. Zedoaria* (AR ; ME) ; *Elettaria Cardamomum* var. *major* \* ; *E. Cardamomum* var. *minuscula* (ME) ; *Languas Galanga* (ME) ; *L. officinarum* \* ; *Zingiber officinale* (D ; AR ; ME).

**ORCHIDACEAE** : *Cephalanthera latifolia* \* ; *C. Xiphophyllum* \* ; *Gymnadenia conopsea* (Br. ; F ; Tr.) ; *Ophrys apifera* (F) ; *O. fuciflora* (Br. ; Tr.) ; *Orchis latifolia* (M ; ME) ; *O. maculata* (ME ; F) ; *O. militaris* (ME ; Br. ; F ; Tr.) ; *O. morio* (D. ; R ; ME ; Br. ; F) ; *Platanthera bifolia* (ME ; F) ; *P. ohlorantha* \* ; *Spiranthes aestivalis* (Tr.) ; *S. spiralis* (D ; Br.).

**PIPERACEAE** : *Piper Cubeba* (AR ; ME) ; *P. longum* (AR ; ME) ; *P. nigrum* (T ; D ; AR ; ME).

**MYRICACEAE** : *Myrica Gale* (P ; ME).

**FAGACEAE** : *Quercus Cerris* (T ; C ; R ; ME).

**MORACEAE** : *Chlorophora tinctoria* \* ; *Ficus Carica* (AES, 1884 ; BC, p. 301 ; T ; R ; ME ; F ; Tr.).

**URTICACEAE** : *Parietaria officinalis* (D ; R ; ME ; Br. ; F ; Tr.) ; *Urtica urens* (T ; ME ; Br. ; F ; Tr.).

**SANTALACEAE** : *Santalum album* (BC, p. 295 ; Nirukta, 5th century B.C., *vide* Flückiger and Hanbury, 1879 ; ME).

**ARISTOLOCHIACEAE** : *Asarum europaeum* (D ; M ; ME ; Br. ; F ; Tr.).

**RAFFLESIACEAE** : *Cytinus Hypocistis* (D ; M ; ME ; Mattioli, 1554).

**POLYGONACEAE** : *Polygonum amphibium* (ME) ; *P. Bistorta* (ME ; Br. ; F ; Tr.). *Rheum palmatum* and/or *Rh. officinale* (AR, ME) ; *Rh. Rhaiponticum* (D ; NM ; ME).

**CHENOPODIACEAE** : *Chenopodium Botrys* (D ; R ; F ; Tr.) ; *Ch. Vulvaria* \*.

**AMARANTHACEAE** : *Celosia argentea* var. *margaritacea* (sp., ME ; var., F ; Tr.).

**PORTULACACEAE** : *Portulaca oleracea* (AEL ; BC, p. 310 ; T ; R ; ME ; F ; Tr.).

**CARYOPHYLLACEAE** : *Herniaria glabra* (T ; M ; ME ; Br. ; Tr.) ; *Stellaria media* (ME ; Br. ; F ; Tr.) ; *Vaccaria pyramidata* (Tr. ; Anguillara, 1561).

**NYMPHAEACEAE** : *Nuphar luteum* (T ; M ; ME ; Br. ; F ; Tr.) ; *Nymphaea alba* (T ; R ; ME ; Br. ; F ; Tr.).

**RANUNCULACEAE** : *Aconitum Napellus* subsp. *pyramidale* (sp., M ; ME) ; *A. Stoerkianum* (Tr.) ; *Adonis aestivalis* (Tr.) ; *A. aestivalis* var. *citrina* \* ; *A. vernalis* (ME ; Tr.) ; *Anemone Hepatica* (M ; ME ; Br. ; Tr.) ; *A. nemorosa* (Br. ; F ; Tr.) ; *A. Pulsatilla* (Br. ; F ; Tr.) ; *A. ranunculoides* (F ; Tr.) ; *A. sylvestris* \* ; *Caltha palustris* (ME ; Tr.) ; *Delphinium Consolida* (ME ; Br. ; F ; Tr.) ; *Helleborus foetidus* (C ; D ; ME ; F) ; *H. viridis* (M ; ME ; Br. ; F ; Tr.) ; *Nigella arvensis* (ME ; F) ; *N. damascena* (M ; ME ; F ; Tr.) ; *N. sativa* (BC, p. 301 ; N ; D ; R ; ME ; F) ; *Paeonia officinalis* (ME ; F ; Tr.) ; *Ranunculus acris* (M ; ME) ; *R. arvensis* (F) ; *R. bulbosus* (ME ; Br. ; F) ; *R. Ficaria* (T ; ME ; Br. ; F ; Tr.) ; *R. Flammula* (ME) ; *R. polyanthemus* (P) ; *R. repens* (Tr.) ; *R. repens* var. *flore pleno* (Br. ; F) ; *R. sardous* (R) ; *R. sceleratus* (ME ; F ; Tr.) ; *Thalictrum angustifolium* (ME) ; *Th. flavum* (M ; ME ; Crescentius, 1471).

**MENISPERMACEAE** : *Anamirta Cocculus* (ME ; Ruellius, 1536, *Orientis cocci*).

**ANNONACEAE** : *Xylopia aethiopica* (ME ; Ibn el Beithar, 13th century A.D.).

**MYRISTICACEAE** : *Myristica fragrans* (ME).

**LAURACEAE** : *Cinnamomum Cassia* (T ; D ; AR ; ME) ; *C. zeylanicum* (BC, p. 298 ; D ; AR ; ME).

**PAPAVERACEAE**: *Corydalis cava* (ME; Br.; F; Tr.); *C. intermedia* \*; *Glaucium flavum* (T; R; N; D; ME; F; Tr.); *Papaver dubium* var. *Lecoquii* \*; *P. somniferum* (T; R; ME; Br.; F).

**CRUCIFERAE**: *Anastatica hierochuntica* (ME; Eur. Cordus, 1534); *Conringia orientalis* \*; *Dentaria bulbifera* \*; *D. enneaphyllos* (P) \*; *Eruca vesicaria* (T; R; ME; F; Tr.); *Lepidium campestre* (F; Tr.); *L. latifolium* (D; R; ME; Br.; F; Tr.); *Turritis glabra* \*.

**MORINGACEAE**: *Moringa oleifera* (D; P; AR; ME).

**DROSERACEAE**: *Drosera intermedia* (Gesner, 1555); *D. rotundifolia* (Tr.).

**CRASSULACEAE**: *Sedum mite* \*; *S. Rosea* (N; D; F; Tr.).

**SAXIFRAGACEAE**: *Parnassia palustris* (D); *Saxifraga aizoon* \*.

**HAMAMELIDACEAE**: *Liquidambar orientalis* (Aetius, 6th century A.D.; Paulus Aegineta, 7th century; ME).

**PLATANACEAE**: *Platanus orientalis* (BC, p. 298; T; R; ME; Mattioli, 1554).

**ROSACEAE**: *Agrimonia Eupatoria* (D; R; ME; Br.; F; Tr.); *Alchemilla vulgaris* (M; ME; Br.; F; Tr.); *Amygdalus Persica* (C; D; ME; F); *Comarum palustre* (Dodoens, 1554); *Cotoneaster integerrimus* \*; *Crataegus Azarolus* (ME; Mattioli, 1554); *C. monogyna* (Tr.); *Cydonia oblonga* (T; R; ME; F; Tr.); *Filipendula hexapetala* (T; ME; F; Tr.); *Fragaria vesca* (P; R; M; ME; Br.; F; Tr.); *Malus pumila* (T; R; ME; Br.); *Potentilla erecta* (M; ME; Br.; F; Tr.); *P. recta* (ME: var. *obscura*, Br.); *Poterium Sanguisorba* (M; ME; F); *Prunus Mahaleb* (T; P; R; ME); *Pyrus communis* (T; C; D; ME; Tr.); *Sanguisorba officinalis* (N; D; ME; F; Tr.); *Sorbus torminalis* (P; R; ME; Tr.).

**LEGUMINOSAE**: *Acacia arabica* and/or *A. Senegal* (T; ME); *Anagyris foetida* (N; D; R; Tr.); *Astragalus fasciculifolius* (Dioscorides, as 'Sarcocolla'; Ibn el Beithar, 13th century A.D.); *A. glycyphyllos* (Tr.); *A. gummifer* (BC, p. 311; Dioscorides as 'Tragacantha'); *Caesalpinia echinata* \*; *Cassia fistula* (NM; AR; ME); *C. obovata* (ART; F; Tr.); *Cicer arietinum* (T; R; ME; Br.; F; Tr.); *Cytisus nigricans* \*; *C. ratisbonensis* \*; *Genista sagittalis* (Tr.); *G. tinctoria* (R; ME; F; Tr.); *Glycyrrhiza glabra* (T; M; ME; Br.; F); *G. glabra* var. *glandulifera* (Tr.); *Laburnum anagyroides* (T; P; ME); *Lathyrus montanus* \*; *L. niger* \*; *L. sativus* (AES, 1887; T; R; ME; F); *L. sylvestris* (F; Tr.); *Lupinus albus* (T; R; ME; F; Tr.); *Medicago sativa* (T; C; D; ME); *Phaseolus vulgaris* (F; Tr.); *Pterocarpus santalinus* (BC, p. 294; AR; ME); *Sarothamnus scoparius* (ME; Br.; F; Tr.); *Spartium junceum* (T; R; ME; F); *Tamarindus indica* (T; ME); *Trigonella caerulea* (F; Tr.); *T. Foenum-graecum* (T; R; ME; F; Tr.); *Vicia Faba* (AES, 1884; BC, p. 296; T; R; ME; Br.; F; Tr.); *Vigna unguiculata* (T; R; NM; AR; ME).

OXALIDACEAE : *Oxalis Acetosella* (ME ; Br. ; F ; Tr.).

GERANIACEAE : *Erodium cicutarium* (ME ; Br. ; F ; Tr.).

ZYGOPHYLLACEAE : *Guaiacum officinale* (discovered in Santo Domingo in 1514—*vide* Flückiger and Hanbury, 1879, 101).

RUTACEAE : *Citrus Aurantium* (R ; ME ; Tr.) ; *C. Limetta* var. *Pomum-Adami* (Mattioli, 1554) ; *C. Limon* (Matth. Sylv., Lib. Pandect. cap. 508 ; Tr.) ; *C. medica* (BC, p. 299 ; T ; ME ; Tr.) ; *C. sinensis* (introduced into Europe in the 14th century ; Tr.) ; *Dictamnus albus* (M ; ME ; A, vi. § 327 ; Br. ; Tr.) ; *Ruta graveolens* subsp. *hortensis* (BC, p. 310 ; T ; R ; ME ; Br. ; F ; Tr.) ; *Ruta montana* \*.

BURSERACEAE : *Boswellia Carterii* (T ; AR, as '*B. thurifera* ') ; *B. Frereana* (15th century, *fide* Flückiger & Hanbury, 1879, 148) ; *B. serrata* \* ; *Commiphora africana* (ME) ; *C. Molmol* (BC, p. 306 : T ; ME) ; *C. Mukul* (T) ; *C. Opobalsamum* (BC, p. 295 ; T ; RD ; ME).

EUPHORBIACEAE : *Emblica officinalis* (NM ; AR ; ME) ; *Euphorbia Chamaesyce* (D ; R ; Mattioli, 1554) ; *E. dulcis* var. *lasiocarpa* (sp., ME) \* ; *E. Peplus* (T ; ME ; F) ; *E. resinifera* (ME) ; *Mercurialis perennis* (T ; F) ; *Ricinus communis* (BC, p. 369 ; T ; R ; Br. ; F ; Tr.).

ANACARDIACEAE : *Pistacia cappadocica* (*P. Terebinthus* × *vera*) (Belon, 1553) ; *P. Lentiscus* (T ; C : D ; ME) ; *P. Terebinthus* (BC, p. 313 ; T ; V ; C ; D ; ME) ; *P. vera* (BC, p. 306 ; T ; N ; D ; ME) ; *Rhus coriaria* (T ; C ; D : ME ; Mattioli, 1554) ; *Semecarpus Anacardium* (G ; ME).

CELASTRACEAE : *Euonymus europaeus* (T ; ME ; Tr.).

ACERACEAE : *Acer campestre* (T ; P ; R ; ME ; Tr.) ; *A. Pseudo-Platanus* (T ; V ; P ; ME ; Tr.).

SAPINDACEAE : *Cardiospermum Halicacabum* (F ; Tr.).

BALSAMINACEAE : *Impatiens Balsamina* (F).

RHAMNACEAE : *Paliurus Spina-Christi* (BC, p. 296 ; T ; N ; V ; C ; D ; ME ; Mattioli, 1554) ; *Rhamnus catharticus* (M : ME ; Crescentius, 1471 ; Tr.) ; *Zizyphus Jujuba* (*Z. sativa*) (R ; Tr. ; Mattioli, 1554) ; *Z. Lotus* (T ; V ; C ; D ; ME).

MALVACEAE : *Althaea officinalis* (T ; R ; ME ; Br. ; F ; Tr.) ; *Malva crispa* \* ; *M. rotundifolia* (R ; ME ; Br. ; F ; Tr.) ; *M. sylvestris* (T ; R ; ME ; Br. ; F).

TAMARICACEAE : *Myricaria germanica* (M ; ME ; F ; Tr.).

CISTACEAE : *Cistus creticus* (D ; ME) ; *C. monspeliensis* (ME ; Mattioli, 1554) ; *C. salviifolius* (BC, p. 303 ; T ; D ; R ; Mattioli, 1554) ; *Helianthemum nummularium* (Tr.).

**THYMELAEACEAE**: *Aquilaria Agallocha* (BC, p. 295; Dioscorides, as 'agallochon'); *Daphne Cneorum* (N; V; C); *D. striata* \*.

**ELAEAGNACEAE**: *Hippophaë Rhamnoides* (ME; Mattioli, 1554).

**PUNICACEAE**: *Punica Granatum* (BC, p. 309; T; C; D; ME; Tr.).

**COMBRETACEAE**: *Terminalia Bellerica* (ME); *T. Chebula* (ME).

**MYRTACEAE**: *Eugenia caryophyllata* (ME).

**ONAGRACEAE**: *Chamaenerium angustifolium* (Gesner, 1553); *Ch. Dodonaei* \*; *Epilobium hirsutum* (R; F; Tr.); *E. montanum* \*; *E. parviflorum* (Gesner, 1553); *E. roseum* \*.

**HYDROCARYACEAE**: *Trapa natans* (T; D; M; ME; Tr.).

**HIPPURIDACEAE**: *Hippuris vulgaris* (T; Mattioli, 1554).

**UMBELLIFERAE**: *Aethusa Cynapium* (ME); *Ammi majus* (M; ME; F; Tr.); *A. Visnaga* (6th century—*vide* Journ. Bot. 1922, 213; Anguillara, 1561); *Apium graveolens* (AES, 1887; T; R; ME; Br.; F; Tr.); *Archangelica officinalis* (M; ME; Br.; F; Tr.); *Bupleurum falcatum* (Tr.); *B. rotundifolium* (R; ME; Br.; F; Tr.); *Carum Carvi* (N; C; D; ME; F; Tr.); *Conium maculatum* (T; R; ME; F; Tr.); *Coriandrum sativum* (AEL; T; R; ME; Br.; F; Tr.); *Crithmum maritimum* (R; ME; Mattioli, 1554); *Cuminum Cyminum* (BC, p. 300; T; N; C; D; ME; Br.; Tr.); *Dorema Ammoniacum* (ME); *Ferula alliacea* and/or *F. foetida* (*Asafoetida*: GD; C; D; AR; ME); *F. galbaniflua* (RD); *Levisticum officinale* (C; D; ME; Br.; F; Tr.); *Meum athamanticum* (A; ME; Br.; F; Tr.); *Myrrhis Odorata* (R); *Opopanax Chironium* (ME); *O. orientale* (N; C; D); *Peucedanum officinale* (T; M; ME; F; Tr.); *P. Oreoselinum* \*; *P. Ostruthium* (ME; Br.; F; Tr.); *P. palustre* (ME; Dodoens, 1554); *Pimpinella Anisum* (T; R; ME; Br.; F; Tr.); *P. nigra* \*; *P. saxifraga* (R; ME; Br.; Tr.); *Seseli annuum* (ME); *S. Libanotis* \*; *Silaum Silaus* \*; *Sison Amomum* (F; Tr.; Anguillara, 1561); *Smyrnum Olusatrum* (T; R; ME; F); *Thapsia garganica* (T; Cr.; N; R; ME; Mattioli, 1554); *Tordylium maximum* \*; *Torilis rubella* \*.

**CORNACEAE**: *Cornus Mas* (T; V; C; ME; Tr.); *C. sanguinea* (T; R; ME; Br.; Tr.).

**ERICACEAE**: *Ledum palustre* (ME) \*; *Oxycoccus quadripetalus* \*.

**PRIMULACEAE**: *Cyclamen europaeum* (N; M; ME; F; Tr.).

**EBENACEAE**: *Diospyros Lotus* (T; ME).

**STYRACACEAE**: *Styrax Benzoin* (Ibn Batuta, 14th century, as 'benjoin'); *S. officinalis* (BC, p. 312; T; D; R; ME; Mattioli, 1554).

**OLEACEAE**: *Fraxinus Ornus* (T; V; R; AR; ME; Anguillara, 1561); *Jasminum officinale* (M; ME; Mattioli, 1554); *Olea europaea* (BC, p. 309; T; R; ME; Tr.); *Phillyrea latifolia* \*; *P. media* (T; Mattioli, 1554).

**LOGANIACEAE**: *Strychnos Nux-vomica* (AR; ME).

**GENTIANACEAE**: *Gentiana germanica* \*; *G. lutea* (D; M; ME; F; Tr.); *G. Pneumonanthe* (Dodoens, 1559); *Menyanthes trifoliata* (ME) \*.

**ASCLEPIADACEAE**: *Vincetoxicum officinale* (D; ME; Br.; F; Tr.).

**CONVOLVULACEAE**: *Calystegia Soldanella* (M; ME; Dodoens, 1554); *Convolvulus Scammonia* (T; ME); *Operculina Turpethum* (AR).

**BORAGINACEAE**: *Anchusa azurea* (N; R; ME; F; Tr.); *A. officinalis* (M; ME; Br.; F); *Borago officinalis* (M; ME; Br.; F; Tr.); *Cordia Myxa* (T; C; ME; Tr.); *Heliotropium europaeum* (N; D; ME; Mattioli, 1554); *Lithospermum arvense* (ME; F; Tr.); *L. officinale* (D; M; ME; F; Tr.); *Lycopsis arvensis* (F; Tr.); *Pulmonaria officinalis* subsp. *obscura* (sp., P; ME); *Symphytum officinale* var. *ochroleucum* (sp., D; R; ME; var., Br.; F; Tr.); *S. officinale* var. *purpureum* (Br.; F.).

**VERBENACEAE**: *Vitex Agnus-Castus* (T; N; D; R; ME; Mattioli, 1554).

**LABIATAE**: *Ajuga Chamaepitys* (N; D; M; ME; F; Tr.); *Coridothymus capitatus* (T; V; C; D); *Glechoma hederacea* (M; ME; Br.; F); *Hyssopus officinalis* (D; R; ME; Br.; F; Tr.); *Lavandula latifolia* (T; ME; F; Tr.); *L. officinalis* (M; F; Tr.); *L. Stoechas* (D; R; ME; F; Tr.); *Marrubium peregrinum* (T); *Mentha Pulegium* (T; R; ME; Br.; F; Tr.); *M. sylvestris* (N; C; D; ME; F; Tr.); *Ocimum Basilicum* var. *majus* (Br.; F; Tr.); *O. Basilicum* var. *minimum* (ME; F; Tr.); *O. Basilicum* var. *vulgare* (sp., T; R; ME; var., F); *Origanum hirtum* \*; *O. Majorana* (T; ME; F; Tr.); *Rosmarinus officinalis* (AEL; C; D; ME; Br.; F; Tr.); *Satureja hortensis* (C; R; ME; F; Tr.); *S. Nepeta* var. *nepetoides* (Mattioli, 1554); *S. Thymbra* (T; N; D; ? A, i, § 138); *Stachys arvensis* \*; *S. germanica* (M; ME; F; Tr.); *S. officinalis* (A; ME; Br.; F; Tr.); *Teucrium Chamaedrys* (T; D; R; ME; F; Tr.); *T. montanum* (D; Mattioli, 1554); *T. Polium* (T; N; D; M; ME); *T. Scorodonia* (P; Tr.); *Thymus vulgaris* (C; R; Br.; F; Tr.).

**SOLANACEAE**: *Capsicum annuum* (F; Tr.); *Datura Metel* (AR; ME; F; Tr.); *Mandragora autumnalis* \*; *M. officinarum* (sp. aggr., BC, p. 304; T; B; AR; ME); *M. vernalis* (F; Tr.); *Physalis Alkekengi* (D; M; ME; Br.; F; Tr.); *Solanum Melongena* (AR; M; ME; F; Tr.); *S. nigrum* (T; M; ME; Br.; F); *S. miniatum* \*.

**SCROPHULARIACEAE**: *Gratiola officinalis* (M; ME; Mattioli, 1558); *Lathraea Squamaria* (ME) \*; *Verbascum Blattaria* (F; Tr.).

**PLANTAGINACEAE:** *Plantago Coronopus* (T; D; ME; F; Tr.); *P. indica* (F; Tr.).

**CAPRIFOLIACEAE:** *Lonicera alpigena* \*; *Viburnum Lantana* (V; R; ME); *V. Opulus* (R; Tr.); *V. Opulus* var. *roseum* \*.

**ADOXACEAE:** *Adoxa Moschatellina* (Tr.).

**VALERIANACEAE:** *Nardostachys Jatamansi* (BC, p. 312; T; ME); *Valeriana celtica* (N; V; D; P; ME); *V. Phu* (ME; F; Tr.; Mattioli, 1554).

**DIPSACACEAE:** *Dipsacus fullonum* (D; M; ME; F); *D. sylvestris* (R; ME; Br.; F; Tr.).

**CUCURBITACEAE:** *Bryonia alba* (N; C; D; ME); *B. dioica* (M; ME; F; Tr.); *Citrullus Colocynthis* (BC, p. 302; M; ME; F; Tr.); *Cucumis Melo* (BC, p. 305; R; ME; F); *Cucurbita Pepo* (R; ME; F); *Ecballium Elaterium* (T; N; D; M; ME; F; Tr.); *Lagenaria vulgaris* (AES, 1884; T; R; ME; Br.; F; Tr.); *Momordica Balsamina* (AEL; M; ME; F; Tr.).

**COMPOSITAE:** *Achillea Ageratum* (D; M; Tr.); *A. Millefolium* (M; ME; Br.; F; Tr.); *A. nobilis* (ME; Tr.); *Anthemis tinctoria* (D; ME; F; Tr.); *Artemisia Abrotanum* (D; R; Br.; F; Tr.); *A. Absinthium* (T; R; ME; Br.; F; Tr.); *A. Absinthium* var. *insipida* \*; *A. campestris* var. *lednicensis* \*; *A. Cina* (ME); *A. Dracunculus* (M; ME; Ruellius, 1537; Mattioli, 1558); *A. pontica* (D; M; ME; F); *A. vulgaris* (B; M; ME; Br.; F; Tr.); *Aster Amellus* (T; V; C; ME; F; Tr.); *Carthamus tinctorius* (AES, 1884; T; M; ME; Br.; F; Tr.); *Centaurea Calcitrapa* (BC, p. 296; T; ME; Br.); *C. Centaurium* (V; R; ME; Anguillara, 1561); *C. Rhapontica* (Euricius Cordus, 1534; Tr.); *Chrysanthemum Parthenium* (T; R; ME; Br.; F; Tr.); *Cichorium Endivia* (BC, p. 303; V; C; D; ME; F; Tr.); *C. Intybus* (BC, p. 303; T; R; ME; Br.; F; Tr.); *Cnicus benedictus* (T; ME; F; Tr.); *Crepis foetida* \*; *Cynara Scolymus* var. *aculeata* (T; R; ME; F; Tr.); *Doronicum Pardalianches* (D; ME; Dodoens, 1559); *Echinops sphaerocephalus* (F); *Erigeron acer* (Gesner, 1553); *Helichrysum italicum* (ME); *Inula Britannica* (D); *I. Conyza* (Mattioli, 1554); *I. germanica* (ME; Tr.); *I. Helenium* (T; R; ME; Br.; F; Tr.); *I. hirta* \*; *I. salicina* (M; ME); *Lactuca perennis* (Mattioli, 1554); *L. Scariola* (T; D; R; ME; F); *L. virosa* (R; ME; Br.; Tr.); *Petasites hybridus* (D; F; Tr.); *Prenanthes purpurea* \*; *Pulicaria vulgaris* (ME; Tr.; Mattioli, 1554); *Santolina Chamaecyparissus* (D; R; ME; F; Tr.); *Saussurea Lappa* (BC, p. 298; T; D, *Costus arabicus*; RD); *Scorzonera humilis* \*; *Sonchus asper* (R; ME; F); *S. oleraceus* (D; R; ME; F); *Tagetes patula* (F); *Tanacetum Balsamita* (GD; M; ME; Tr.); *T. vulgare* (M; ME; Br.; F; Tr.); *Tragopogon pratensis* (M; ME; F; Tr.); *Tussilago Farfara* (D; R; ME; Br.; F; Tr.); *Xanthium strumarium* (D; ME; Br.; F; Tr.).

## 6. ENUMERATION OF THE PLANTS DESCRIBED AND FIGURED.

This part of the paper was prepared in the following way. All references to the 'Historia' contained in Caspar Bauhin's 'Pinax' were first extracted, the citation from the 'Pinax' being appended in each case. The corresponding names in Linné's 'Species Plantarum' were then obtained from Richter's 'Codex', and the modern name, where different from that of Linné, was added. In this way a large body of provisional identifications was compiled, each of which was checked by us with the description given by Cordus and the figure (if any) supplied by Gesner. The best results were secured by comparing the *descriptions* in the 'Historia', as well as the figures, with *illustrations* of the species concerned, the points described by Cordus being usually such as are represented better in a drawing than in a modern technical description.

In numerous cases Caspar Bauhin failed to cite plants described by Valerius Cordus, or Linné failed to cite the names given by Bauhin; in other cases the resulting identifications proved to be wrong. It was then necessary to study the descriptions in the 'Historia' in detail, and occasionally to translate them into English, re-arranging them in the form of a modern technical description. This was done for *Tithymallus pentaclonus* V. Cord. (no. 53), which had not previously been identified correctly. By comparing the re-written description with the plates in Reichenbach's 'Icones Florae Germanicae' and the descriptions in Hegi's 'Ill. Fl. Mitteleur.', it was possible, by a process of elimination, to identify *Tithymallus pentaclonus* with *Euphorbia dulcis* var. *lasiocarpa*. From description, *Ixopus* V. Cord. (no. 55) obviously belonged to the Compositae-Cichorieae: Cordus stated that it was a herb of the Chicory kind (*intybacea herba*) with the root full of milky juice, and the florets (*capillamenta*) turning into pappi and flying off, with the achenes (*semina*) attached below. Inspection of the plates in Reichenbach showed that the only two possible genera were *Tragopogon* and *Scorzonera*, the leaves being radical, long, narrow, acuminate (and presumably unlobed), and the scapes unbranched. By a process of exclusion, *Ixopus* was then run down to *Scorzonera humilis*.

The identification of the exotic fruit known as *Carpesium* (no. 375) offered a problem of a different nature. The description of the fruit at once suggested that of an aggregate fruit of Annonaceae, and in particular the genus *Xylopia*: 'pediculi ab arbore exeunt in rotundum, et crassius capitulum desinentes, a quo undique plures exeunt teretes fructus, ut plurimum incurvi, deorsum pendentes, figura siliquacei, foris nigri, ac velut geniculati, modiceque apparentibus angustius, brevi intervallo praecincti'. This idea was supported by the taste being acrid, hot, and aromatic. On investigation *Carpesium* was found to be *Xylopia aethiopica*, the 'Negro Pepper' of West Africa, although Cordus stated that it was imported into Germany from Syria and Asia: 'simul ad nos ex Syria Asiaque affertur'. This identification was then confirmed by reference to Dunal's monograph of the Annonaceae. Wherever possible,



individual identifications were checked in this way with monographs or revisions.

Finally, all the identifications from the 'Historia' given by Dierbach (1825-33) and Schulz (1916) were checked.

The Enumeration is arranged on the following general plan. A running number is prefixed to the synonymy of each plant. Where the illustrations supplied by Gesner represent different plants from those of Cordus, the same running number is used, but is followed by the letter 'A' for the description and 'B' for the illustration. The name used in the 'Historia' is cited first. This is succeeded by a reference to the 'Annotationes', if the plant is mentioned there. The corresponding name, if any, used by Thalius (1588) follows, together with a reference to the identification of it by Schulze (1905). Then come references to Caspar Bauhin's 'Pinax', to A. P. De Candolle's identifications of plants in Bauhin's herbarium, to Juel's identifications of plants in Burser's herbarium, which was named in accordance with the 'Pinax', and to Savage's edition of Linné's determinations of plants in Burser's herbarium. References are given also to Haller's 'Enumeratio', where he cites plants from the 'Historia'. The name used in the 'Species Plantarum', and the accepted name, if it is different, then follow. Other synonyms are given only where necessary. References to useful illustrations and to works on medical and economic botany follow, preceded by a dash. Finally, references (if any) to works earlier than the 'Historia' are appended, preceded by another dash.

The following abbreviations are employed :—

B.P.C. British Pharmaceutical Codex, 1934.

Br. Brunfels : the number cited is the running-number in Sprague (1928).

B.T. Bentley and Trimen, Medicinal Plants (1880).

C. Candolle, A. P. De, L'herbier de Gaspard Bauhin (Bull. Herb. Boiss. 2e série, iv. : 1904).

C.B.P. Caspar Bauhin, Pinax Theatri Botanici (1623).

Dr. Dragendorff, Die Heilpflanzen (1898).

F. Fuchs : the number cited is the running-number in Sprague and Nelmes (1931).

F.H. Flückiger and Hanbury, Pharmacographia, ed. 2 (1879).

H. Holland, Overseas Plant Products (1937).

J. Juel, Joachim Burser's Hortus Siccus (Symb. Bot. Upsal. II : 1 : 1936).

L.P. Leclerc, Précis de Phytothérapie (1922).

L.Sp. Linn. Sp. Pl., ed. 1 (1753).

P.C. Potter's Cyclopaedia of Botanical Drugs and Preparations, ed. 2 (1915).

R. Rosenthal, Synopsis Plantarum diaphoricarum (1862).

S. Savage, Caroli Linnaei determinationes in hortum siccum Joachimi Burseri (Catalogue of the manuscripts in the Library of the Linnean Society of London Part II. 1937).

Sch. Schulze, Index Thalianus (Zeitschr. für Naturwiss. Bd. 77, 1905).

Th. Thalius, Sylva Hercynia (1588).

Tr. Tragus, Stirp. Comment. (1552) : where a '!' follows the page number, the figure in Cordus is borrowed from Tragus.

\* Tsch. Tschirch, Handbuch der Pharmakognosie, ed. 1 (1908-27).

*Liber I : De herbis diversis.*

1 A. *Rorella sive Salsirora*, 86 r., excl. ic. *Salsirora, sive Ros solis*, var. *masculus* Th. t. 9, fig. 1 ; Sch. 33. *Ros Solis folio rotundo* C.B.P. 357 a ; C. 740 ; J. 133 ; S. 67. *Rorella caule simplici, foliis rotundis retusis* Hall. Enum. 372. *Drosera rotundifolia* L. Sp. 281.—Dreves et Hayne, Choix Pl. Eur. III, t. 74 ; Engl. Pflanzenr. Droserac. 95, fig. 32 A ; P.C. 276 ; L.P. 195 ; R. 656.—Tr. 528, ic. infer. dextr. tantum.

Cordus described the leaves as spoon-shaped and spread out in a circle on the ground, and the scape as under nine inches in length. These details indicate *D. rotundifolia*.

1 B. *Rorella sive Salsirora*, 86 r., quoad ic. tantum. *Ros Solis* Dod. Pempt. 471 (1583). *Salsirora, sive Ros solis*, var. *fuemella* Th. t. 9, fig. 2. *Ros Solis folio oblongo* C.B.P. 357 b, partim. *Drosera longifolia* L. Sp. 282, partim. *Drosera intermedia* Hayne.—Dreves et Hayne, Choix Pl. Eur. III, 43, t. 75 B ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XIII, t. 1292 ; R. 657 ; Dr. 265.—*Ros Solis* Gesner, Rar. Admirand. Herb. 37, ic. fere eadem (1555).

2. *Limnesium sive Centauris*, 86 r., ic. 86 v. *Gratiola centauroides* C.B.P. 279 a ; C. 726 ; J. 104 ; S. 52. *Gratiola* Hall. Enum. 618. *Gratiola officinalis* L. Sp. 17.—Berg et Schmidt, Offiz. Gewächse. IV, t. 28 C ; P.C. 127 ; L.P. 9 ; R. 476.—*Gratiola* Gesn. Op. ed. Schmidel, II, fasc. 2, 64, t. 31, no. 100 (1770).

The figure was reproduced from a crude one in Gesner's collection. A later and better figure is given in Gesn. Op. loc. cit.

3. *Sagitta sive Sagittalis*, 86 v., ic. 87 r. *Sagitta aquatica minor latifolia* C.B.P. 194 a ; C. 459 ; S. 32. *Sagittaria foliis sagittatis*, var.  $\delta$ , Hall. Enum. 301. *Sagittaria sagittifolia* L. Sp. 993.—Redouté, Liliacées, v, tt. 279, 280 ; R. 80 ; Dr. 76 ; H. 92.

4. *Bistorta*, 87 r., cum ic. ; Annot. Diosc. 61 v., cap. 2 ; Gesn. in Annot. Diosc. 62 v., nota marginali. *Bistorta major radice minus intorta* C.P.B. 192 a ; C. 312 ; J. 65 ; S. 31. *Polygonum Bistorta* L. Sp. 360.—Bonnier, Fl. Compl. IX, t. 530, fig. 2409 ; B.T. 212 ; P.C. 28 ; L.P. 99 ; R. 219.—Br. 13, 14 ; Tr. 321 !

5. *Carduus sphaerocephalus*, 87 r., ic. 87 v. *Carduus Sphaerocephalus latifolius vulgaris* C.B.P. 381 a ; C. 741 ; J. 139 ; S. 70. *Echinops sphaerocephalus* L. Sp. 814.—Fl. Dan. XIII, t. 2179 ; R. 295 ; Dr. 685.—F. 503.

6. *Sena*, 87 v., ic. 88 r. *Senna Italica sive foliis obtusis* C.B.P. 397 a. *Cassia Senna*, var.  $\beta$ , L. Sp. 377. *Cassia obovata* Colladon.—Berg et Schmidt, Offiz. Gewächse, II, t. 9 B ; B.T. 89 ; R. 1037 ; Dr. 302 ; Dalziel, Useful Pl. W. Trop. Afr. 180.—F. 253 ; Tr. 964 !

7. *Piperitis sive Siliquastrum Peruvianum*, 88 r., cum ic. *Piper Indicum vulgatissimum* C.B.P. 102 a ; J. 30 ; S. 15. *Capsicum annuum* L. Sp. 189.—Köhler, Med. Pfl. I, 127, cum tab. ; B.T. 189 ; R. 457 ; Dr. 595.—F. 418 ; Tr. 928 !

8. *Balsamella*, 88 v., cum ic. *Balsamina foemina* C.B.P. 306 b ; J. 114 ; S. 57. *Impatiens Balsamina* L. Sp. 938.—Regnault, Bot. II, t. 117 ; R. 898 ; Dr. 410.—F. 106.

9. *Dorycnium*, 89 r., cum ic. ; Annot. Diosc. 67 r. (*Granacordis et Halicacabum*). *Pisum vesicarium fructu nigro, alba macula notato* C.B.P. 343 a ; J. 127 ; S. 64. *Cardiospermum Halicacabum* L. Sp. 366.—Sprague et Gray, Gen. III. II, t. 181 ; R. 776 ; Dr. 407.—F. 394 ; Tr. 897 !

\*10. *Anblatum*, 89 r., ic. 89 v. ; Th. 7 ; Sch. 7. *Orobanche radice dentata major* C.B.P. 88 a ; J. 24 ; S. 13. *Squamaria* Riv. Fl. Irreg. Monopet. t. 89 ; Hall. Enum. 611. *Lathraea Squamaria* L. Sp. 606.—Hegi, Ill. Fl. VI, pars I, t. 244, fig. 2 ; R. 497 ; Dr. 614.

11. *Helianthemum*, 89 v., cum ic. ; Th. 57 ; Sch. 19. *Chamaecistus vulgaris flore luteo* C.B.P. 465 a ; C. 747 ; J. 154. *Helianthemum foliis subhirsutis, omnibus longe ellipticis* Hall. Enum. 358. *Cistus nummularius* L. Sp. 527. *Cistus Helianthemum* L. Sp. 528. *Helianthemum nummularium* (L.) Mill. (*H. Chamaecistus* Mill. ; *H. vulgare* Gaertn.).—Bonnier, Fl. Compl. II, t. 62, fig. 300 ; R. 656 ; Dr. 447.—Tr. 221 !

12. *Hyoscyamus Peruvianus*, 90 r., cum ic. *Solanum pomo spinoso rotundo, longo flore* C.B.P. 168 a ; J. 54 ; S. 26. *Datura Metel* L. Sp. 179.—Bot. Mag. t. 1440 ; R. 453 ; Dr. 598 ; H. 48, 49.—F. 396 ; Tr. 896 !

13. *Gingidium*, 90 r., ic. 90 v. ; Annot. Diosc. 45 v. *Gingidium umbella oblonga* C.B.P. 151 a ; J. 46. *Daucus Visnaga* L. Sp. 242. *Ammi Visnaga* (L.) Lam.—Jacq. Hort. Vindob. III, t. 26 ; R. 531 ; Dr. 488 ; H. 4, 57.—F. 448 ; Dodoens, Cruydeb. 655 (1554) ; Dodoens, Comm. Imag. II, 160 (1554).

The figure, taken from Dodoens according to Gesner, is rather crude, and has relatively short and broad leaf-segments such as are found on young plants of *A. Visnaga* (e.g. Porta et Rigo in Herb. Kew).

14. *Melongena*, 90 v., ic. 91 r. *Solanum pomiferum fructu oblongo* C.B.P. 167 b ; C. 308 ; J. 54 ; S. 26. *Solanum Melongena* L. Sp. 186.—Regnault, Bot. I, 68 ; R. 464 ; Dr. 591.—F. 301 ; Tr. 894 !

15. *Scorodonia*, 91 r., cum ic. ; Th. 111 ; Sch. 32. *Scordium alterum, sive Salvia syvestris* C.B.P. 247 b ; J. 89 ; S. 44. *Chamaedrys foliis cordatis, scapis florigeris nudis, spicatis, longissimis* Hall Enum. 632. *Teucrium Scorodonia* L. Sp. 565.—Syme, Engl. Bot. VII, t. 1093 ; P.C. 305 ; L.P. 126 ; R. 423.—Tr. 15 !

A bad figure, with acutely serrate (instead of orenate) leaves and inverted corollas. The footnote, 'Hindtleube. Est scordium Montanum Odi', was added by Ömler.

16. *Polyacantha*, 91 v., cum ic. *Carduus stellatus foliis papaveris erratici* C.B.P. 387 a ; C. 742 ; J. 141 ; S. 71. *Calcitrapa foliis laxè pinnatis, mollibus, capitulis ad latera caulis sessilibus* Hall. Enum. 689. *Centaurea Calcitrapa* L. Sp. 917.—Plenck, Ic. Pl. Med. vii, t. 636 ; Bonnier, Fl. Compl. vi, t. 325, fig. 1593, 1593 bis ; L.P. 119 ; R. 299.—Br. 157 ; Dodoens, Cruydeb. 555 (1554).

Figure adapted from the one in Dodoens (loc. cit.), with the addition of a capitulum.

17. *Tanacetum Perunianum*, 92 r., sine ic. *Tanacetum Africanum, seu flos Africanus minor* C.B.P. 133 a ; J. 38 ; S. 19. *Tagetes minor, flore fulvo maculato* Dill. Hort. Elth. 373, t. 279. *Tagetes patula* L. Sp. 887.—Redouté, Choix, t. 138 ; R. 277 ; Dr. 673.—F. 27.

18. *Helleborus alter niger, vel Helleborine maior*, 92 r., sine ic. *Helleborus niger foetidus* C.B.P. 185 a ; J. 61 ; S. 30. *Helleborus vaginis pallidis, vix serratis, flore virente* Hall. Enum. 317. *Helleborus foetidus* L. Sp. 558.—Plenck, Ic. Pl. Med. v, t. 449 ; R. 611 ; Dr. 222.—F. 155.

\*19. *Aizoom serratum*, 92 r., ic. 92 v. *Cotyledon media foliis oblongis serratis* C.B.P. 285 a ; J. 107. *Saxifraga foliorum ora cartilaginea, crenata, florum spica parva et alba* Hall. Enum. 402. *Sedum aliud montanum, cuius flores albi punctis sanguineis adsparguntur* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. 1, 21 (1759), partim. *Saxifraga Cotyledon* L. Sp. 398, partim. *Saxifraga Aizoon* Jacq. Fl. Austr. v. 18, t. 438 ; Sternb. Rev. Saxifr. 3, t. 3 a.

Recorded by Cordus from Württemberg and Schwaben. *S. Aizoon* is the only white-flowered encrusted saxifrage occurring in Württemberg, according to Martens u. Kienmiller, Fl. Württemberg, ed. 2, 220 (1865).

20. *Aizoom serratum alterum*, ic. 92 v. Possibly *Saxifraga crustata* Vest.—Treated by Haller, Enum. 402, as a variety of the preceding number, with non-punctate petals.

21. *Helleborine tenuifolia*, 92 v. *Helleborinum*, ic. 93 r. *Helleborus niger tenuifolius Buphthalmi flore* C.B.P. 186 a ; J. 62 ; S. 30. *Adonis perennis dodecapetalos* Hall. Enum. 319. *Adonis vernalis* L. Sp. 547.—Plenck, Ic. Pl. Med. v, t. 450 ; P.C. 129 ; L.P. 278 ; R. 606.—Tr. 406 !

22. *Trinitas, id est Epimedium*, 93 r., cum ic. ; Annot. Diosc. 62 v. *Trifolium hepaticum flore simplici* C.B.P. 330 b ; C. 736 ; J. 123 ; S. 62. *Trinitas* Hall. Enum. 320. *Anemone Hepatica* L. Sp. 538.—Plenck, Ic. Pl. Med. v, t. 452 ; Hegi, Ill. Fl. III, 116 ; P.C. 170 ; R. 606.—Br. 68 ; Tr. 519 !

23. *Bechion*, 93 r., ic. 93 v. *Tussilago* Annot. Diosc. 58 r. *Tussilago vulgaris* C.B.P. 197 a ; C. 460 ; J. 67 ; S. 32. *Petasites scapo unifloro, flosculis in ambitu ligulatis* Hall. Enum. 708. *Tussilago Farfara* L. Sp. 820.—Plenck, Ic. Pl. Med. vii, t. 629 ; P.C. 77 ; L.P. 192 ; R. 264.—Br. 8 ; F. 76 ; Tr. 418 !

A composite figure, combining the inflorescences and leaves. The old capitulum is represented as erect instead of drooping.

24 A. *Anchusa minima*, 93 v., excl. ic.; Annot. Diosc. 63 r. *Lithospermum arvense radice rubra* C.B.P. 258 b; C. 474; J. 94; S. 47. *Lithospermum seminibus rugosis, corollis vix calycem superantibus* Hall. Enum. 518. *Lithospermum arvense* L. Sp. 132; Fl. Dan. III, t. 456.—R. 437; Dr. 563.—F. 514; Tr. 534 (*Sylvestre Lithospermon*).

Haller identified *Anchusa minima* Cord. with *Lithospermum arvense radice rubra* C.B.P. This identification is supported by the appearance of the plant in early spring, the description of the root as red and yielding a red dye, and the comparison of the 'seeds' to those of *Echium* [*E. vulgare* L.]; it is confirmed by the German name 'Schminckwurtz' cited for *Anchusa minima* by Cordus (loc. cit. 63 r., cap. 23), and applied in Thüringen to *Lithospermum arvense* L., according to Pritzel and Jessen.

24 B. *Anchusa*, 93 v., quoad ic. tantum. *Buglossum sylvestre minus alterum et asperius* C.B.P. 256 b. *Lycopsis arvensis* L. Sp. 139.—Fl. Dan. III, t. 435; L.P. 69; R. 437.—F. 151; Tr. 234!

25. *Lithospermon*, 93 v., ic. 94 r. *Lithospermum* Annot. Diosc. 60 r. *Lithospermum majus erectum* C.B.P. 258 a; C. 474; J. 94; S. 47. *Lithospermum foliis subtus nervosis, floribus in alis foliorum exeuntibus* Hall. Enum. 518. *Lithospermum officinale* L. Sp. 132.—Fl. Dan. VII, t. 1084; Plenck, Ic. Pl. Med. t. 75; Reichb. Ic. Fl. Germ. XVIII, t. 1313; R. 437; Dr. 563.—F. 277; Tr. 234!

The broad leaves with strongly marked lateral nerves are characteristic of *Lithospermum officinale*.

26. *Filipendula*, 94 r., cum ic.; Annot. Diosc. 58 v., sub *Oenanthe*. *Filipendula vulgaris* C.B.P. 163 b; J. 51; S. 25. *Spiraea Filipendula* L. Sp. 490. *Ulmaria Filipendula* (L.) Hill. *Filipendula hexapetala* Gilib.—Reichb. Ic. Fl. Germ. XXV, t. 78; Sturm, Fl. Deutschl. ed. 2, VIII, t. 13; R. 968; Dr. 272.—F. 319; Tr. 883!

*Medesousium*, with which Cordus (94 v.) compares *Filipendula*, is *Filipendula Ulmaria* (L.) Maxim.

27. *Tormentilla*, 94 v., cum. ic.; Annot. Diosc. 54 v. sub *Quinquefolio*. *Tormentilla sylvestris* C.B.P. 326 a; C. 734; J. 121; S. 60. *Potentilla foliis quinatis, flore tetrapetalo, caule erecto* Hall. Enum. 341. *Tormentilla erecta* L. Sp. 500. *Potentilla erecta* (L.) Hampe.—Reichb. Ic. Fl. Germ. XXV, t. 59; B.T. 101; P.C. 284; L.P. 96; R. 961; H. 219.—Br. 22; F. 146; Tr. 503!

28. *Fraxinella*, 94 v., ic. 95 r. *Dictamnus nostra* Annot. Diosc. 52 r. *Dictamnus albus vulgo sive Fraxinella* C.B.P. 222 a; J. 79; S. 39. *Fraxinella* Hall. Enum. 311. *Dictamnus albus* L. Sp. 383.—Plenck, Ic. Pl. Med. iv, t. 325; R. 882; Dr. 352; H. 51.—Br. 263; Tr. 27!

29. *Dracunculus palustris*, 95 r., ic. 95 v. *Wasser Aron* Annot. Diosc. 48 r., sub *Dracunculo minore*. *Dracunculus palustris, sive radice arundinacea, Plinii* C.B.P. 195 b; C. 459; J. 66; S. 32. *Calla palustris* L. Sp. 968. *Dreves* et Hayne, Choix Pl. Eur. t. 87; R. 142; Dr. 103.—F. 481.

30. *Pentaphyllon palustre*, 95 v., ic. 96 r. *Quinquefolium palustre rubrum* C.B.P. 326 b ; C. 734 ; J. 120 ; S. 60. *Comarum* Hall. Enum. 337. *Comarum palustre* L. Sp. 502.—Fl. Dan. iv, t. 636 ; Dreves et Hayne, Choix Pl. Eur. t. 92 ; R. 961 ; Dr. 277.—*Pentaphyllon rubrum* Dodoens, Cruydeb. 100 (1554).

\*31. *Trifolium palustre*, 96 r., ic. 96 v. *Trifolium palustre*, seu *Trifolium Castoris* Th. 125 ; Sch. 34. *Trifolium palustre* C.B.P. 327 a ; C. 734 ; J. 121 ; S. 60. *Menoanthes foliis ternatis* Hall. Enum. 487. *Menyanthes trifoliata* L. Sp. 145.—Plenck, Ic. Pl. Med. I, t. 87 ; B.T. 184 ; P.C. 41 ; L.P. 124 ; R. 392.

\*32. *Brassica sylvestris virgata*, 96 v., sine ic. *Sinapi album* Dalech. Hist. II, 1168 (1586). *Brassica sylvestris foliis circa radicem Cichorei modo infectis* C. Bauh. Phytopinax, 179 (1596). *Brassica sylvestris ramosa tota pene glabra* C. Bauh. Cat. Pl. Basil. 33 (1622). *Brassica sylvestris foliis circa radicem cichoraceis* C.B.P. 112 b ; C. 215. *Turritis foliis radicalibus dentatis hispidis, caulinis integerrimis, amplexicaulibus glabris* L. Hort. Cliff. 339 ; Hall. Enum. 560 (sp. 2, II). *Turritis glabra* L. Sp. 666.—Fl. Dan. v, t. 809 ; Reichb. Ic. Fl. Germ. II, t. 44, fig. 4346 ; R. 631 ; Dr. 259.

Apparently a much-branched state of *Turritis glabra*. Haller (loc. cit.) referred *Brassica sylvestris ramosa tota pene glabra* C. Bauh. to this species, since he could find no other Swiss plant with which it could be identified.

33. *Victorialis foemina*, id est, *sylvestris Gladiolus*, 97 r., cum ic. *Victorialis rotunda aut foemina* Annot. Diosc. 63 r., sub *Gladiolo*. *Gladiolus palustris* Gaud. ; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. xxxiii, 52 (1916).—Reichb. Ic. Fl. Germ. IX, t. 351 ; Hegi, Ill. Fl. II, t. 66, fig. 2 ; R. 111 ; Dr. 140.

The description of the corm tunics as reticulate suggests *G. palustris* rather than *G. imbricatus* L., in which the meshes are narrow and inconspicuous. *G. palustris* has been recorded from several localities in the neighbourhood of Halle, where Cordus found it in abundance (Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, iv. 62).

34 A. *Thalictrum nigrum*, 97 v., excl. ic. ; Th. 121 ; Sch. 33. *Verum Thalictrum, quam Germani Heyleblat appellant* Annot. Diosc. 69 v. *Thalictrum majus siliqua angulosa aut striata* C.B.P. 336 a. *Thalictrum caule folioso, striato, panicula multiplici terminatrici*, var.  $\beta$ , Hall. Enum. 308. *Thalictrum flavum* L. Sp. 546.—Jacq. Fl. Austr. v, 10, t. 421 (*T. nigricans* Jacq.) ; Reichb. Ic. Fl. Germ. III, t. 43 ; R. 602 ; Dr. 227.

Cordus described this plant as occurring in meadows and having a single perennial root [rhizome], yellow inside, with numerous fibres [roots] and leaves intermediate between the lower leaves of Coriander and those of Rue, green above and ash-coloured below. He mentioned also that the whole plant had a bitter and somewhat acrid taste. According to Cordus (69 v.),

the true *Thalictrum* Diosc. was a herb called Heyleblat in Germany, and used as a vulnerary in Saxony. These details indicate *T. flavum* which, according to Syme, Engl. Bot. i, 10, is very acrid and has a yellow root yielding a yellow dye. Dragendorff, Heilpfl. 227, states that the root of *T. flavum* (*T. nigricans*) is used as a diuretic and purgative, and Pritzel and Jessen, Deutsch. Volksn. Pfl. 400, refer Heyleblat of Cordus to this species. The specimen in C. Bauhin's herbarium has been identified (C. 737) as *Thalictrum aquilegifolium* L.

34 B. *Thalictrum nigrum*, 97 v., quoad ic. tantum. The figure supplied by Gesner cannot be identified with certainty. Haller, Enum. 309, referred it to *Thalictrum seminibus triangularibus pendulis, stipulis ad divisiones petiolorum*, which is *Thalictrum aquilegifolium* L. Lecoyer, Monogr. Thalictr. 6, on the other hand, identified it as probably *T. minus* L. (Reichb. Ic. Fl. Germ. III, t. 27).

35 A. *Thalictrum tenuifolium*, 97 v., excl. ic. *Thalictrum angustissimo folio* C. Bauh. Prodr. 146 (1620). *Thalictrum pratense angustissimo folio* C.B.P. 337 b; J. 126; S. 63. *Thalictrum foliis lanceolato-linearibus integerrimis* L. Hort. Cliff. 226 (1737). *Thalictrum caule folioso, foliis angustissimis non dentatis* Hall. Enum. 307. *Thalictrum foliis ascendentibus, linearibus, panicula erecta* Hall. Hist. 56. *Thalictrum angustifolium* L. Sp. 546.—Jacq. Hort. Vindob. III, 25, t. 43; R. 603.

Cordus described this plant as occurring in damp meadows and swampy places, and having several roots not so woody, fleshier, and not so yellow as that of his *T. nigrum*, a somewhat slenderer and more deeply grooved stem, leaves green on both surfaces, with thin narrow segments one inch long or more and not serrate, and flowers smelling of *Sambucus*. These details point to *T. angustifolium* L., which, according to Jacquin (loc. cit.), has flowers with a strong scent resembling that of *Sambucus*.

35 B. *Thalictrum tenuifolium*, 98 r., quoad ic. tantum. The figure supplied by Gesner cannot be identified with certainty. Haller, Enum. 308, referred it to *Thalictrum foliis latis, subrotunde tridentatis, caule nudo, laxo paniculato*, which is *Thalictrum minus* L. Lecoyer, Monogr. Thalictr. 6, also thought that it might be a variety of *T. minus*. Sprengel, Gesch. Bot. i, 279, on the other hand, identified the figure as *Thalictrum tuberosum* L., but the roots are represented as cylindric, not expanded into ellipsoid or ovoid tubers. Gesner realized that the figure did not correspond with the description, for he remarked: 'Ea cuius hic effigiem damus herba, si non *Thalictrum leptophyllum* Cordi est, genere tamen proximo continetur.'

\*36. *Aizoon minimum* 98 r., sine ic. *Aizoon minus seu Vermicularis insipida* Th. 7; Sch. 7. *Sempervivum minus vermiculatum insipidum* C.B.P. 284 a. *Sedum foliis conicis, floribus in alis sessilibus majoribus, luteis* Hall. Enum. 396. *Sedum foliis teretibus, ternatis, caulibus simplicibus, trifidis* Hall. Hist. i, 415. *Sedum sexangulare* L. Sp. 432, partim. *Sedum mite* Gilib. Fl. Lithuan. II,

182 (*Sedum boloniense* Lois.).—Zenker, Fl. Thüringen, v, t. 579; Reichb. Ic. Fl. Germ. xxii, t. 57, fig. 1; Praeger in Journ. R. Hort. Soc. XLVI, 265, fig. 155; R. 575.

Said to differ from *Aizoon minus* Cord., Annot. 68 v. (*Sedum rupestre* L. or *S. reflexum* L.), in its smaller stems and leaves, and from *Aizoon acre* (*Sedum acre* L.) in the flowers being distichously arranged on branchlets an inch or more in length.

37. *Millegrana*, 98 r., ic. 98 v. *Herniaria* Thal. Sylv. Hercyn. 56 (1588). *Polygonum minus seu Millegrana major* C.B.P. 281 b; C. 727; J. 105; S. 52. *Herniaria calycibus bractea nudis* Hall. Enum. 182. *Herniaria glabra* L. Sp. 218.—Syme, Engl. Bot. vii, t. 1171; P.C. 241; L.P. 65; R. 696.—Br. 236; Tr. 527!

\*38. *Astragalus*, 98 v., sine ic.; Annot. Diosc. 66 r. *Astragalus sylvaticus* Th. 7, t. 1; Sch. 7. *Astragalus sylvaticus foliis oblongis glabris* C.B.P. 351 b; C. 739; J. 131; S. 66. *Orobis caule non ramoso, foliis imis ovatis, supernis ellipticis acutis* Hall. Enum. 603. *Astragalus Germanicus, Christianwurz* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. II, 38, t. 24, no. 80, fig. A (1770). *Orobis tuberosus* L. Sp. 728. *Lathyrus montunus* Bernh.—Dietr. Fl. Boruss. vii, t. 484; R. 1008; Dr. 332.

Cordus described the form with broad leaflets, shown in Gesner's t. 24, fig. A, which was sent to Gesner by Aemylius (Georg Ömler).

39. *Nymphaea alba*, 98 v., ic. 99 r. *Nymphaea* Annot. Diosc. 59 r. *Nymphaea alba major* C.B.P. 193 a; C. 459. *Nymphaea calyce tetraphyllo, fructu rotundo* Hall. Enum. 302. *Nymphaea alba* L. Sp. 510.—Reichb. Ic. Fl. Germ. vii, t. 67; L.P. 230; R. 653.—Br. 7; F. 302; Tr. 696!

40. *Nymphaea citrina*, 99 r., ic. 99 v. *Altera Nymphaea* Annot. Diosc. 50 r. *Nymphaea lutea major* C.B.P. 193 b; C. 459. *Nymphaea calyce magno pentaphyllo, fructu pyriformi* Hall. Enum. 302. *Nymphaea lutea* L. Sp. 510. *Nuphar luteum* (L.) Sibth. et Sm.—Arber, Water Plants, frontispiece, et loc. cit. 27, fig. 12; Arber, Herbals, 142, fig. 67; R. 653; Dr. 210.—Br. 6; F. 303; Tr. 697!

41. *Cicer nigrum*, 99 v., cum. ic. *Cicer, tertium genus* Annot. Diosc. 43 r. *Cicer sativum* C.B.P. 347 a; C. 738; J. 129; S. 65. *Cicer arietinum* L. Sp. 738 (Chick Pea).—Regnault, Bot. II, t. 95; R. 1004; Dr. 331; H. 30.—Br. 253; F. 150; Tr. 609!

42. *Foenograecum*, 100 r., cum. ic.; Annot. Diosc. 43 r. *Foenumgraecum sativum* C.B.P. 348 a; J. 129; S. 65. *Trigonella Foenumgraecum* L. Sp. 777.—Regnault, Bot. II, 88; B.T. 71; P.C. 103; R. 989; H. 59.—F. 454; Tr. 597!

\*43. *Pastinaca nigra sylvestris*, 100 r., sine ic. *Seseli pratense* C.B.P. 162 b; J. 51; S. 25. *Peucedanum Silaus* L. Sp. 246. *Silaum Silaus* (L.) Schinz



et Thell. (*S. flavescent* Bernh. ; *S. pratensis* Bess.).—Jacq. Fl. Austr. i, 12, t. 15 ; Hayne, Arzn. Gewächse, vii, t. 5 ; R. 539 ; Dr. 493.

Referred doubtfully by Haller, Enum. 442, to *Peucedanum pinnis duplicato pinnatis, foliis angustis, breviter trifidis*, which is *Selinum Carvifolia* L. This has white flowers, whereas Cordus stated that the flowers were yellow.

44. *Caron*, 100 v., cum ic. *Carum* Annot. Diosc. 54 v. *Cuminum pratense, Carui Officinarum* C.B.P. 158 a ; C. 307 ; J. 49 ; S. 24. *Carum* Hall. Enum. 428. *Carum Carvi* L. Sp. 263.—Plenck, Ic. Pl. Med. iii, t. 214 ; B.T. 121 ; P.C. 55 ; L.P. 137 ; R. 531 ; H. 23.—F. 224 ; Tr. 455 !

45 A. *Phasiolus minor sativus*, 101 r., excl. ic. *Lathyrus sativus flore fructuque albo* C.B.P. 343 a ; C. 737 ; J. 127. *Lathyrus foliis binatis gramineis, petiolis unifloris, siliqua latissima, superne alata* Hall. Enum. 594. *Lathyrus sativus* L. Sp. 730.—Jacq. Ecl. ii, t. 116 ; R. 1007 ; Dr. 331 ; H. 137.—F. 324.

45 B. *Phasiolus*, 100 v., quoad ic. tantum. *Lathyrus foliis binatis elliptico lanceolatis floribus racemosis* Hall. Enum. 595. *Lathyrus sylvestris* L. Sp. 733.—Dietr. Fl. Boruss. viii, t. 568 ; Reichb. Ic. Fl. Germ. xxii, t. 211 ; R. 1008.—F. 325 ; Tr. 613 !

The figure, originally adapted from Fuchs, Imagines, 329 (1545), is a bad representation of *Lathyrus sylvestris* L., with the inflorescences shown as only 2-flowered.

46. *Phalaris*, 101 r., cum ic. ; Annot. Diosc. 60 r. *Phalaris major semine albo* C.B.P. 28 a. *Phalaris canariensis* L. Sp. 54.—Plenck, Ic. Pl. Med. i, t. 41 ; R. 55 ; Dr. 83 ; H. 21.—Tr. 669 !

47. *Asparagus*, 101 r., ic. 101 v. ; Annot. Diosc. 44 v. *Asparagus sativa* C.B.P. 489 a ; J. 160. *Asparagus officinalis* var. *γ altilis* L. Sp. 313.—Regnault, Bot. ii, t. 40 ; P.C. 16 ; L.P. 40 ; R. 96 ; H. 8.—F. 33 ; Tr. 222 !

48. *Althaea seu Malva palustris*, 101 v., cum ic. *Althaea* Annot. Diosc. 60 r. *Althaea Dioscoridis et Plinii* C.B.P. 315 a ; C. 731 ; J. 116 ; S. 58. *Althaea officinalis* L. Sp. 686.—Regnault, Bot. i, t. 20 ; Dietr. Fl. Boruss. iv, t. 280 ; B.T. 35 ; P.C. 182 ; L.P. 191 ; R. 705.—Br. 186 ; F. 7 ; Tr. 371 !

49. *Phu maius*, 102 r., cum ic. *Phu* Annot. Diosc. 3 r. *Valeriana hortensis* C.B.P. 164 a ; J. 52 ; S. 25. *Valeriana Phu* L. Sp. 32.—Reichb. Ic. Fl. Germ. xii, t. 725 ; R. 255 ; Dr. 644.—F. 489 ; Tr. 60 !

50. *Helleborus niger nostras*, 102 v., cum ic. *Veratrum nigrum* Annot. Diosc. 73 v. *Helleborus niger hortensis flore viridi* C.B.P. 185 b ; J. 61 ; S. 30. *Helleborus vaginis foliaceis digitatis, flore virente* Hall. Enum. 317. *Helleborus viridis* L. Sp. 558.—Jacq. Fl. Austr. ii, t. 106 ; R. 611 ; Dr. 221.—Br. 5 ; F. 154 ; Tr. 405 !

51. *Aron*, 102 v., ic. 103 r., *Arum* Annot. Diosc. 48 r. *Arum vulgare non maculatum* C.B.P. 195 b ; J. 119 ; S. 32. *Arum maculatum, maculis candidis*,

*vel nigris* C.B.P. 195 a ; J. 119 ; S. 32. *Arum foliis sagittatis cucullo recto* Hall. Enum. 261. *Arum maculatum* L. Sp. 966.—Dietr. Fl. Boruss. iv, t. 223 ; Bonnier, Fl. Compl. xi, t. 617 ; P.C. 89 ; L.P. 215 ; R. 139.—Br. 12 ; F. 39 ; Tr. 774 !

52. *Perfoliata*, 103 (sphalm. 104) r., cum ic. *Perfoliata vulgarissima, sive arvensis* C.B.P. 277 a ; C. 725 ; J. 103 ; S. 52. *Bupleurum foliis ovatis perfoliatis* Hall. Enum. 437. *Bupleurum rotundifolium* L. Sp. 236.—Regnault, Bot. II, t. 54 ; R. 534 ; Dr. 486.—Br. 64 ; F. 360 ; Tr. 482 !

\*53. *Tithymallus pentactonius*, 103 v., sine ic. *Esula dulcis* Lob. Hist. 193 (1576). *Pityusa seu Esula minor altera floribus rubris* Lob. Ic. 358 (1591). *Tithymalus montanus non acris* C.B.P. 292 b ; J. 110 ; S. 55. *Esula solissequa* Riv. Fl. Irreg. Tetrapet. t. 117 (1691). *Tithymalus dulcis tuberosa radice* Barrel. Pl. Ic. 6, n. 45, fig. 909 (1714). *Tithymalus foliis ad caulem subhirsutis, ellipticis, brevibus sub floribus binis, cordatis, capsularum media parte verrucosa* Hall. Enum. 190. *Euphorbia dulcis* L. Sp. 457, var. *lasiocarpa* Neilr. Fl. Nieder-Oesterr. 845 (1859).—Jacq. Fl. Austr. III, 8, t. 213 ; Dietr. Fl. Boruss. XII, t. 820 ; Reichb. Ic. Fl. Germ. v, t. 134, fig. 4759 (*E. solissequa*).

Cordus described *T. pentactonius* as having a horizontal, much-branched, fleshy rhizome ; slender terete stems with oblong leaves ; a 5-rayed cyme with 2-rayed branches subtended by shorter and apiculate leaves [bracts], each secondary ray bearing a pair of smaller leaves and a solitary tertiary ray with a similar but smaller pair ; additional axillary branches below the terminal cyme ; an obtusely triquetrous somewhat hirsute capsule ; and seeds with a sweet kernel. These characters, taken together, point to *Euphorbia dulcis* var. *lasiocarpa*, and exclude all the other middle European species. The only apparent discrepancies are the description of the stem and leaves as glabrous and the seeds as black. The stems of *E. dulcis* are sparingly pilose, and the leaves are more or less pilose beneath, but a small amount of indumentum was often not observed by sixteenth-century (and later) botanists. As to the colour of the seeds, which are brown in *E. dulcis*, the words 'niger' and 'candidus' were frequently used at that time in the general sense of 'dark' and 'pale' respectively.

Referred by Dierbach (Beitr. Deutschl. Fl. iv, 27 : 1833) to *Euphorbia platyphyllos* L., an annual plant, with very acrid latex !

\*54. *Daucus angulosus* (*D. angulosicaulis*), 103 v., sine ic. ; Th. 37, in obs. *Libanotis alba minor, seu amara* Th. 71 ; Sch. 21. *Libanotis minor apii folio* C.B.P. 157 b. *Daucus angulosus Cordi* J. Bauh. Hist. III, pars 2, 58 b, in obs. *Libanotis* Riv. Fl. Irreg. Pentapet. t. 37 (1699). *Athamanta Libanotis* L. Sp. 244. *Libanotis montana* Crantz. *Seseli Libanotis* (L.) Koch.—Jacq. Fl. Austr. iv, 48, tt. 392, 392\* ; R. 538 ; Dr. 492.

The description given by Cordus is unmistakable, salient characters being the whitish root, acrid and leaving a burning taste, the sheath of fibres

surrounding the crown of the root, the angular stem, the long axillary branches each terminated by an umbel, and the convex dense umbels of very small white flowers.

August Schulz (1916, p. 60) identified *Daucus angulosicaulis* as *Peucedanum Cervaria* (L.) Cuss., in which the root is *black* outside, full of yellowish latex, the stem is *terete*, and the umbels are *straggling* (Jacq. Fl. Austr. i, 44, t. 69). Cordus makes no mention of latex in *Daucus angulosicaulis*, although he is careful to mention its occurrence in other plants.

\*55. *Ixopus*, 104 r., sine ic. *Chondrillae viscosae affinis* C.B.P. 130 a. *Scorzonera humilis* L. Sp. 790.—Dietr. Fl. Boruss. ix, t. 598; Reichb. Ic. Fl. Germ. xix, t. 1883, II; Lindm. Bild. Nordens Fl. t. 40; Hegi, Ill. Fl. vi, pars 2, 1057, fig. 742; R. 308; Dr. 693.

Cordus described *Ixopus* as a herb of the Chicory kind with numerous acuminate leaves, nine inches long and one inch broad, spreading or obliquely ascending from the crown of the root; with one or two, or sometimes several slender scapes (coliculi) bearing, towards the middle of spring, solitary capitula (orbiculati flores) of yellow florets (capillamenta) in an involucre (calix), the florets passing into pappi and flying off with the longish achene (semen) attached below; the root perennial, one foot long, two fingers' breadth thick, black outside, white inside, fleshy and spongy; when cut, it yields a copious supply of a greyish-white latex, which, when worked with the fingers or tongue, becomes like bird-lime and can be drawn out into a long string, and when dried becomes red and by degrees black; the whole herb is sweet to the taste, and the latex actively astringent but without smell. The plant grows in lofty sunny places on mountains, and likes a rich soil with a strong admixture of calcareous stone, and for that reason occurs near Jena.

By a process of exclusion, *Ixopus* has been identified as *Scorzonera humilis*, which is calciphilous, occurs at Jena (Hegi, loc. cit. 1058), and fits the description. A closely related species, *S. austriaca* Willd., has white latex which turns orange on exposure to air (Jacq. Fl. Austr. i, 24, t. 36).

Haller (Enum. 757) referred *Ixopus* to his *Scorzonera* no. 2, which, according to the figures given by Mattioli, Tabernaemontanus, and Morrison, whom he cited, has a branched flowering stem, bearing several capitula. The description of *Ixopus* is inconsistent with *Chondrilla juncea* L., to which, by an extraordinary error, it was referred by Dierbach (Beitr. Deutschl. Fl. ii, 73: 1828).

56. *Thamnecnemum*, 104 r., ic. 104 v. *Lychnis segetum rubra foliis perfoliatae* C.B.P. 204 b; C. 462; J. 70; S. 34. *Saponaria caule brachiato, calyce pentagono turgido* Hall. Enum. 379. *Saponaria Vaccaria* L. Sp. 409. *Vaccaria pyramidata* Medik.—Reichb. Ic. Fl. Germ. vi, t. 245; R. 699; Dr. 206.—Tr. 130.

57. *Lavandula maior*, 104 v., cum ic. *Lavandula maior, sive Spica* Annot. Diosc. 52 r. *Lavandula latifolia* C.B.P. 216 a, *Lavandula Spica*, var.  $\beta$ ,

L. Sp. 572. *Lavandula latifolia* Vill. (Spike).—Bonnier, Fl. Compl. VIII, t. 468 ; R. 397 ; Dr. 571 ; H. 94, 194.—F. 507 ; Tr. 58 !

58. *Lavandula minor*, 105 r., cum ic. *Lavendula vulgaris* Annot. Diosc. 52 r. *Lavandula angustifolia* C.B.P. 216 a ; J. 77. *Lavandula Spica*, var.  $\alpha$ , L. Sp. 572. *Lavandula officinalis* Chaix.—Bonnier, Fl. Compl. VIII, t. 468, as *L. Spica* ; B.T. 199 ; P.C. 161 ; L.P. 166 ; R. 397 ; H. 94.—F. 508 ; Tr. 57 !

59. *Stichas Arabica*, 105 r., cum ic. ; Annot. Diosc. 52 r. *Stoechas purpurea* C.B.P. 216 a ; J. 77 ; S. 38. *Lavandula Stoechas* L. Sp. 573.—Bonnier, Fl. Compl. VIII, t. 468 ; R. 398 ; Dr. 571.—F. 444 ; Tr. 213 !

60. *Dipsacus sylvestris*, 105 v., cum ic. *Labrum Veneris* . . . *Quaedam sponte provenit* Annot. Diosc. 50 v. *Dipsacus sylvestris* aut *Virga pastoris major* C.B.P. 385 b ; J. 141. *Dipsacus capitulis ovalibus, calycis foliis sulcatis, dentatis, aristis glumarum rectis* Hall. Enum. 673. *Dipsacus fullonum*, var.  $\alpha$ , L. Sp. 97. *Dipsacus sylvestris* Huds.—Jacq. Fl. Austr. v, t. 402 ; R. 256 ; Dr. 645.—Br. 126 ; F. 127 ; Tr. 847 !

61. *Dipsacus sativus*, 106 r., sine ic. *Labrum Veneris, seu Carduus fullonum* Annot. Diosc. 50 v. *Dipsacus sativus* C.B.P. 385 a ; J. 141. *Dipsacus fullonum*, var.  $\beta$ , L. Sp. 97. *D. fullonum* L. emend. Huds.—R. 256 ; Dr. 645 ; H. 212.—F. 126.

62. *Peplus*, 106 r., cum ic. ; Annot. Diosc. 75 r. *Peplus, Esula rotunda* Th. 90 ; Sch. 27. *Peplus, sive Esula rotunda* C.B.P. 292 a ; J. 110 ; S. 55. *Tithymalus foliis ad caulem ovatis, sub floribus binis, cordatis, obtusissimis, umbellae radiis paucis vagisque* Hall. Enum. 193. *Euphorbia Peplus* L. Sp. 456.—Curt. Fl. Lond. I, fasc. I, t. 35 ; R. 814.—F. 342.

63. *Parietaria*, 106 r., ic. 106 v. *Helvine altera* Annot. Diosc. 64 r. *Parietaria Officinarum et Dioscoridis* C.B.P. 121 a ; C. 297. *Parietaria* Hall. Enum. 177. *Parietaria officinalis* L. Sp. 1052.—Curt. Fl. Lond. II, fasc. iv, t. 63 ; P.C. 210 ; L.P. 46 ; R. 201.—Br. 91 ; F. 156 ; Tr. 193 !

64. *Botrys*, 106 v., cum. ic. ; Annot. Diosc. 58 v. *Botrys Ambrosioides vulgaris* C.B.P. 138 a ; C. 302 ; J. 40 ; S. 20. *Chenopodium Botrys*, L. Sp. 219.—Reichb. Ic. Fl. Germ. xxiv, t. 250 ; L.P. 175 ; R. 210.—F. 100 ; Tr. 887 !

Referred to *Teucrium Botrys* L. by Dierbach (Beitr. Deutschl. Fl. III, 56 : 1830), who cannot have read the description given by Cordus.

65. *Abrotonum nigrum seu masculum*, 107 r., cum ic. ; Annot. Diosc. 51 v. *Abrotonum mas angustifolium majus* C.B.P. 136 a ; J. 40 ; S. 19. *Artemisia Abrotonum* L. Sp. 845.—Woodville, Med. Bot. ed. 2, I, t. 21 ; Hayne, Arnz. Gewächse, XI, t. 22 ; P.C. 265 ; R. 286 ; H. 193.—Br. 267 ; F. 3 ; Tr. 341 !

The figure from Tragus, supplied by Gesner, is a bad adaptation of the poor figure in Fuchs, Hist. 6, and is almost unrecognizable. •

\*66 A. *Abrotonum candidum seu foemina*, 107 r., excl. ic. 107 v. *Abrotonum candidum* (Wilde Stabwurtz, Weisse Stabwurtz) Annot. Diosc. 51 v. *Artemisia campestris* L., var. *lednicensis* Rochel sensu Hegi, Ill. Fl. vi, pars 2, 668.—Hayne, Arzn. Gewächse, II, t. 9; Zenker, Fl. Thüringen, v, t. 525; Dietr. Fl. Boruss. IX, t. 635; Syme, Engl. Bot. v, t. 733; R. 286; Dr. 680; Tsch. II, 1002, 1021.

Cordus (Annot. Diosc. 51 v.) stated that *Abrotonum candidum*, besides being cultivated in gardens, grew wild in many places in Germany. The habitat, 'nascitur editis campis', is consistent with *Artemisia campestris* var. *lednicensis*.

66 B. *Abrotonum candidum*, 107 v., quoad ic. tantum. *Absinthium Ponticum tenuifolium incanum* C.B.P. 138 b.; J. 40; S. 20. *Artemisia pontica* L. Sp. 847.—Jacq. Fl. Austr. I, t. 99; Hayne, Arzn. Gewächse, II, t. 10; R. 287; Dr. 678; Tsch. II, 1002, 1021.—F. 4: *Abrotonum foemina* Fuchs, Hist. 7 (1542). *Absinthium Ponticum* Fuchs, Imag. 3 (1545); V. Cordus, Dispens. 237 (1546); Dodoens, Hist. Pl. ed. Clusius, 3 (1557). *Absinthium Romanum*, V. Cordus, Dispens. 147 (1546).

Cordus (Dispens. 237) stated that the German druggists did not possess *Absinthium Ponticum*.

67. *Hyssopus saliva*, 107 v., cum ic. *Hyssopus* Annot. Diosc. 51 v. *Hyssopus officinarum caerulea, sive spicata* C.B.P. 217 a; J. 77; S. 38. *Hyssopus officinalis* L. Sp. 569.—Plenck, Ic. Pl. Med. v, t. 465; P.C. 140; L.P. 198; R. 411.—Br. 265; F. 479; Tr. 47!

68. *Cepa ovata*, 108 r., sine ic. *Cepa plurium caulium* C.B.P. 71 b. Evidently one of the many races of *Allium Cepa* L.

69. *Thlaspi cardamoides*, 108 r., cum ic. *Thlaspi minus* Annot. Diosc. 46 v. *Thlaspi arvense Vaccariae incano folio majus* C.B.P. 106 a. *Nasturtium (Thlaspi) siliculis subrotundis, foliis sagittatis dentatis incanis* Hall. Enum. 544. *Thlaspi campestre* L. Sp. 646. *Lepidium campestre* (L.) R. Br.—Bonnier, Fl. Compl. I, t. 57, fig. 274; R. 638; Dr. 252.—Tr. 87!

70. *Isophyllon*, 108 r., ic. 108 v. *Bupleuron folio rotundo, sive vulgatissimum* C.B.P. 278 a; C. 726; J. 103; S. 52. *Bupleurum foliis petiolatis, falcato-ellipticis, acutis* Hall. Enum. 439. *Bupleurum falcatum* L. Sp. 237.—Syme, Engl. Bot. IV, t. 592; R. 535; Dr. 486.—Tr. 431!

71. *Geranium supinum maius*, 108 v., sine ic. *Geranium Cicutae folio moschatum: et inodorum* C.B.P. 319 a, partim; C. 732. *Geranium pedunculis multifloris, calycibus pentaphyllis, foliis duplicato-pinnatis* Hall. Enum. 369. *Geranium cicutarium* L. Sp. 680. *Erodium cicutarium* (L.) L'Hérit.—Dietr. Fl. Boruss. v, t. 331; R. 888; Dr. 340.—Br. 108; F. 113; Tr. 347.

72. *Urtica minor*, 108 v., ic. 109 r. *Urtica urens minor* C.B.P. 232 a; C. 467; J. 82; S. 41. *Urtica foliis ovatis, amentis cylindraceis androgyna* Hall. Enum.

178. *Urtica urens* L. Sp. 984.—Fl. Dan. v. t. 739 ; R. 199 ; Dr. 179.—Br. 53 ; F. 59 ; Tr. 3 !

73. *Chamaepitys prima*, 109 r., cum ic. *Vera Chamaepitys, seu Iva* Annot. Diosc. 61 r. *Chamaepitys lutea vulgaris sive folio trifido* C.B.P. 249 b ; J. 90 ; S. 45. *Bugula foliis trifidis, floribus sparsis in alis foliorum* Hall. Enum. 634 *Teucrium Chamaepitys* L. Sp. 562. *Ajuga Chamaepitys* (L.) Schreb.—Fl. Dan. v, t. 733 ; P.C. 123 ; R. 424.—F. 505 ; Tr. 80 !

74. *Buglossa urbana*, 109 v., cum ic. *Buglossum* Annot. Diosc. 71 v. *Buglossum latifolium, Borrago* C.B.P. 256 a ; C. 473 ; J. 93 ; S. 46. *Borrago calycibus patentibus* Hall. Enum. 524. *Borago officinalis* L. Sp. 137.—Plenck Ic. Pl. Med. i, t. 77 ; P.C. 36 ; L.P. 68 ; R. 439.—Br. 36 ; F. 77 ; Tr. 237 !

75. *Altera Buglossa urbana*, 109 v., sine ic. *Buglossum latifolium, Borrago* C.B.P. 256 a. *Borrago calycibus patentibus, var. β, flore albo*, Hall. Enum. 524. *Borago officinalis* L. floribus albis.

\*76. *Heracleu (Sideritis Heraclea)*, 110 r., sine ic. Probably *Stachys arvensis* L. Sp. ed. 2, 814.—Dietr. Fl. Boruss. VIII, t. 510.—The flowers are described as 'rubentes', hence it cannot be either Zeyssgenkraut (Gesn. (*Stachys annua* L.)), as suggested by Gesner, or Beruffkraut Gesn. (*Stachys recta* L.), since these species have yellow flowers. The fruiting calyces are described as 'resupinati'. Thalius (Sylv. Hereyn. 105) describes a *Sideritis Cordi*, which Cordus had shown to Amylius (Georg Ömler) and others, but no description of which had been published. This is *Stachys arvensis* L., according to Erwin Schulze, Index Thalianus, 30 (1905).

77. *Panicum*, 110 r., sine ic. *Panicum verum* Annot. Diosc. 42 v. *Panicum Germanicum sive panicula minore* C.B.P. 27 a. *Panicum italicum* L. Sp. 56. *Setaria italica* (L.) Beauv.—Host, Ic. Gram. iv, t. 14 ; R. 58 ; Dr. 82 ; H. 112.—F. 142.

The figure to the left of the description represents *Papaver somniferum* L., and was inserted by mistake.

78. *Pulegium*, 110 r., ic. 110 v. ; Annot. Diosc. 52 r. *Pulegium latifolium* C.B.P. 222 a ; S. 39. *Pulegium foliis rotundis, verticillis nudis* Hall. Enum. 659. *Mentha Pulegium* L. Sp. 577.—Bonnier, Fl. Compl. t. 468, fig. 2173 ; B.T. 201 ; P.C. 211 ; R. 401.—Br. 80 ; F. 110 ; Tr. 23 !

79. *Hordeum glabrum*, 110 v., ic. 111 r. *Hexastichum Hordeum* Annot. Diosc. 42 r. *Zeopyrum seu Triticospeltum* C.B.P. 22 a ; C. Bauh. Theatr. 423. *Hordeum nudum sive Gynnocrithon* J. Bauh. Hist. II, 430. *Hordeum vulgare* var. *coeleste* L. Sp. 84 ; Willd. Sp. i. 472 ; Körnicke-Werner Handb. Getreideb. I, 166.—R. 68.—*Zeopyron* Dod. Imag. ed. 2, II, 362 (1559) ; Dod. Pempt. 486 (1583).

A foreign race of Barley in which the grain was easily separable from the hull. The figure was adapted from the one in Dod. Imag. loc. cit.

\*80 A. *Chamaepeuce*, 111 r., excl. ic.; Annot. Diosc. 61 r., sub *Chamaepitys*; vera *Cordi Chamaepeuce* Th. 116 (in textu *Selaginis species alterae*); Sch. 33. *Cistus ledon foliis rorismarini ferrugineis* C.B.P. 467 b; J. 154. *Ledum palustre* L. Sp. 391.—Plenck, Ic. Pl. Med. iv, t. 337; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzzart. i, t. 51; Dietr. Fl. Boruss. iv, t. 255; R. 522; Dr. 506.

80 B. *Chamaepeuce*, 111 v., quoad ic. tantum. *Selaginis species altera* Th. 116. *Muscus terrestris clavatus* C.B.P. 360 a; J. 134; S. 68. *Lycopodium clavatum* L. Sp. 1101.—Hook. Brit. Ferns, t. 49; Syme, Engl. Bot. xii, t. 1833; R. 49.—Tr. 555!

81. *Mercurialis mascula sylvestris*, 111 v., cum ic.; Annot. Diosc. 76 v. *Mercurialis montana testiculata* C.B.P. 122 a; C. 297. *Mercurialis caule brachiato foliis glabris*, var.  $\beta$ , *Femina*, Hall. Enum. 194. *Mercurialis perennis* L. Sp. 1035 (female plant!).—Syme, Engl. Bot. viii, t. 1268; R. 823; Dr. 379.—F. 251; *Cynocrambe* Matth. Comm. 561 (1554); Dod. Cruydeb. 94 (1554).

Figure copied from Matth. Comm. 561.—The specimen in C. Bauhin's herbarium is male! (C. 297).

82. *Mercurialis foemina sylvestris*, 111 v., sine ic.; Annot. Diosc. 76 v. *Mercurialis montana spicata* C.B.P. 122 a. *Mercurialis caule brachiato foliis glabris*, var.  $\alpha$ , *Mas*, Hall. Enum. 194. *Mercurialis perennis* L. Sp. 1035 (male plant!).

83. *Triticum Bactrianum*, 112 r., cum ic. *Frumentum Indicum Mays dictum* C.B.P. 25 a. *Zea Mays* L. Sp. 971.—Plenck, Ic. Pl. Med. vii, t. 657; B.T. 296; P.C. 82; L.P. 39; R. 54.—F. 470; Tr. 651!

84. *Asarum*, 112 v., ic. 112 r.; Annot. Diosc. 2 v. *Asarum* C.B.P. 197 a; C. 460; J. 66; S. 32. *Asarum* Hall. Enum. 195. *Asarum europaeum* L. Sp. 442.—Reichb. Ic. Fl. Germ. xii, t. 668; P.C. 15; L.P. 20; R. 245.—Br. 17; F. 5; Tr. 64!

85. *Corruda*, 112 v., cum ic.; Annot. Diosc. 44 v., cap. 151. *Asparagus foliis acutis* C.B.P. 490 a; J. 160. *Asparagus acutifolius* L. Sp. 314.—Reichb. Ic. Fl. Germ. x, t. 520, fig. 972; R. 97; Dr. 125.—Vide no. 486.

86. *Phyllitis*, 113 r., ic. 112 v.; Annot. Diosc. 58 r. *Lingua cervina officinarum* C.B.P. 353 a; J. 132; S. 66. *Asplenium frondibus linearibus integris, basi cordatis inflexis, petiolis hirsutis* Hall. Enum. 134. *Asplenium Scolopendrium* L. Sp. 1079. *Phyllitis Scolopendrium* (L.) Newman.—Syme, Engl. Bot. xii, t. 1884; P.C. 126; R. 45.—Br. 110; F. 167; Tr. 549!

87. *Polygonatum tenuifolium*, 113 r., cum ic. *Polygonatum angustifolium non ramosum* C.B.P. 303 b; J. 113; S. 57. *Polygonatum foliis verticillatis* Hall. Enum. 288. *Convallaria verticillata* L. Sp. 315. *Polygonatum verticillatum* (L.) All.—Hegi, Ill. Fl. ii, t. 64, fig. 1; R. 101; Dr. 127.—F. 333; Tr. 400!

88. *Polygonatum*, 113 r., ic. 113 v.; Annot. Diosc. 61 v. *Polygonatum latifolium vulgare* C.B.P. 303 a; C. 730. *Polygonatum foliis alternis, petiolis pendulis multifloris* Hall. Enum. 287. *Convallaria multiflora* L. Sp. 315. *Polygonatum multiflorum* (L.) All.—Redouté, Liliacées, iv, t. 229; Dietr. Fl. Boruss. i, t. 35; P.C. 264; R. 100.—Br. 167; F. 332; Tr. 399!

89. *Polygonatum angulosum*, 113 v., sine ic. *Polygonatum latifolium flore majore odore* C.B.P. 303 b; J. 113. *Polygonatum foliis alternis, petiolis pendulis unifloris* Hall. Enum. 287. *Convallaria Polygonatum* L. Sp. 315. *Polygonatum officinale* All.—Dietr. Fl. Boruss. i, t. 341 (*P. vulgare*); Syme, Engl. Bot. ix, t. 1512; R. 100; Dr. 127.

\*90. *Malva sativa laciniosa*, 113 v. *Malva hortensis crispa*, ic. 114 r. *Roemische Pappeln* Annot. Diosc. 44 v. *Malva foliis crispis* C.B.P. 315 a; J. 116; S. 58. *Malva verticillata*, var.  $\beta$ , L. Sp. 689. *Malva crispa* L. Sp. ed. 2, 970.—Reichb. Ic. Fl. Germ. v, t. 166, fig. 4834; Vilmorin-Andrieux, Pl. Potagères, 330; L. H. Bailey, Stand. Cycl. Hortie. iv, 1974; R. 707.

91. *Malva sylvestris recta*, 114 r., cum ic. *Malva sylvestris vulgaris* Annot. Diosc. 44 v. *Malva sylvestris folio sinuato* C.B.P. 314 a; C. 731; J. 116; S. 58. *Malva caule erecto, foliis fere palmatis, obsolete serratis* Hall. Enum. 362. *Malva sylvestris* L. Sp. 689.—Dietr. Fl. Boruss. iii, t. 191; P.C. 35; L.P. 15; R. 706.—Br. 132; F. 290.

Figure redrawn from Fuchs, Hist. 309.

92. *Ocimum nigrum*, 114 v., cum ic. *Ocimum primum* Annot. Diosc. 45 v. *Ocimum caryophyllatum majus* C.B.P. 226 a; J. 80. *Ocimum Basilicum* L. Sp. 597, var. *majus* Alef. Landwirthsch. Fl. 114.—Regnault. Bot. i, t. 117; P.C. 22; L.P. 168; R. 394.—F. 311; Tr. 31!

\*93. *Intybum nauseosum*, 114 v., sine ic. The brief description suggests a *Crepis*, possibly *C. foetida* L., as identified by Dierbach, Beitr. Deutsch. Fl. ii, 72 (1828). According to Zenker, Fl. Thüringen, ix, t. 1057, the root of that species abounds in a very sharp and evil-smelling latex, and Cordus described the latex of *Intybum nauseosum* as extremely acrid and nauseous.

94. *Colocynthis grandis oblonga*, 114 v., sine ic. *Colocynthis oblonga* C.B.P. 313 b. *Cucurbita Pepo* L. sensu Naud. in Ann. Sc. Nat. sér. 4, vi, 29.—R. 682; H. 152. The size and shape agree with the variety-group *citrullina* Alef. Landwirthsch. Fl. 219 (Citrouilles proprement dites, Naud.), but the very bitter cartilaginous flesh seems to distinguish it from any named form now in cultivation.

95. *Colocynthis grandis rotunda*, 115 r., sine ic. *Cucurbita Pepo* L. Differs from no. 94 in its 5-lobed leaves and rather smaller subglobose fruits, sometimes flattened at base and apex, and marked with raised lines.



96. *Zucha rotunda mediocris*, 115 r., sine ic. *Cucurbita major rotunda flore luteo folio aspero* C.B.P. 312 a ; J. 115. *Cucurbita Pepo* L. Referable to the variety-group *Melopepo* Alef. Landwirthsch. Fl. 220, and possibly to var. *chrysobela* Alef. loc. cit. 221.

97. *Zucha rotunda minor*, 115 r., sine ic. *Cucurbita Pepo* L. Differs from no. 96 in its broader leaves, smaller, more tubercled fruits with more prominent longitudinal ribs, harder rind, and almost saffron-coloured flesh.

98 A. *Colocynthis turbinata*, 115 v., excl. ic. *Colocynthis pyriformis seu Pepo amarus* C.B.P. 313 b. *Cucurbita Pepo* L. Referable to the variety-group *pyriformis* Alef. loc. cit. 224 (Cougourdette, Naud.).

98 B. *Colocynthis turbinata*, 115 v., quoad ic. tantum. *Citrullus Colocynthis* (L.) Schrad.—Tr. 828 !—vide no. 111.

99. *Colocynthis oblonga glabra*, 115 v., sine ic. *Cucurbita Pepo* L. Similar to no. 94, but with smaller, less deeply trilobed leaves and smaller fruits without raised ribs.

100. *Cucurbita Cameraria*, 116 r., cum ic. *Cucurbita lagenaria* L. Sp. 1010. *Lagenaria vulgaris* Ser.—R. 679 ; Dalziel, Useful Pl. W. Trop. Afr. 58 ; H. 66.—*Cucurbitae omnis generis* Tr. 824 !

The figure combines three varieties : (1) var. *turbinata* Ser. ex DC. Prodr. III, 299, et Fl. Jard. II, 488.—F. 209 ; Moris. Hist. i. Sect. 1, t. 5, fig. 2 ; (2) var. *Gourda* Ser. locis cit.—F. 210 ; Moris. loc. cit. fig. 1 ; (3) var. *clavatu* Ser. locis cit.—F. 211 ; Moris. loc. cit. fig. 3.

101. *Cucurbita Plebeia*, 116 v., sine ic. *Cucurbita Indica vulgaris* Rumph. Herb. Amboin. v, 398, t. 144. *Lagenaria vulgaris* Ser. var. *Cougourda* Ser. ex DC. Prodr. III, 299, et Fl. Jard. II, 488.—Lam. Ill. t. 795, fig. 2 b ; Braam, Ic. Pl. Chin. t. 17.

102. *Bryonia nigra*, 116 v., sine ic. *Vitis nigra* Annot. Diosc. 76 r. *Bryonia alba baccis nigris* C.B.P. 297 a ; J. 111. *Bryonia alba* L. Sp. 1012.—Hayne, Gewächse, VI, t. 23 ; P.C. 40 ; R. 673.

103. *Bryonia alba seu ruffa*, 116 v., ic. 117 r. *Vitis alba* Annot. Diosc. 76 r. *Bryonia aspera sive alba baccis rubris* C.B.P. 297 a ; C. 729. *Vitis alba* Fuchs, Hist. 94. *Bryonia foliis quinquangulis scabris* Hall. Enum. 506. *Bryonia dioica* Jacq. Fl. Austr. II, 59, t. 199.—Hayne, Arzn. Gewächse, VI, t. 24 ; L.P. 6 ; R. 673.—Tr. 820 !

The figure of *Vitis alba* Fuchs was previously identified (F. 51) as *Bryonia alba* L. because of the agreement of the root with the figure and description given by Hayne, Arzn. Gewächse, VI, t. 23, but according to Jacquin, Fl. Austr. II, 60, the old root of *Bryonia dioica* Jacq. is also very large and branched. Only male inflorescences are shown by Fuchs, and this suggests *B. dioica* rather than *B. alba*, which is monoecious, with male flowers below and female flowers

above on the same branch. The description of the berries as red also agrees with *B. dioica*, though Fuchs might have copied this from Dioscorides. Finally, *B. dioica* is the only species of *Bryonia* native in Württemberg, where *Vitis alba* Fuchs grew everywhere in hedges and thickets.

104. *Zucha maior longa*, 117 r., sine ic. *Cucurbita Pepo* L. Differs from 94 in the edible nature and sweet taste of the fruit. Referable to the variety-group *citrullina* Alef. Landwirthsch. Fl. 219 (Citrouilles proprement dites, Naud.).

105. *Zucha maior rotunda*, 117 r., sine ic. *Cucurbita major rotunda flore luteo folio aspero* C.B.P. 312 a; J. 115. *Cucurbita Pepo* L., variety-group *Melopepo* Alef. Landwirthsch. Fl. 220.

106. *Zucha grandis rotunda glabra*, 117 v., sine ic. *Cucurbita Pepo* L., variety-group *Melopepo* Alef. Differs from no. 105 in the spherical fruits dark green even at maturity.

107. *Melon*, 117 v., cum ic. *Cucumis Melo* L. Sp. 1011, race-group *Cantalupo* (Ser.) Harz. Landwirthsch. Samenk. II, 778. A race with small or medium-sized fruits, variable in shape and generally over 6 inches in diameter. Apparently near var. *Prescottii* Harz, loc. cit.

108. *Melon moschatellinus*, 118 r., sine ic. *Cucumis Melo* L., race-group *Cantalupo* (Ser.) Harz. Apparently referable to var. *moschatus* Harz, loc. cit. 779.

109. *Pepo*, 118 r., cum ic. *Melo vulgaris* C.B.P. 310 a; J. 115. *Cucumis Melo cantalupensis* Naud. in Ann. Sc. Nat. sér. 4, XI, 47; Alef. Landwirthsch. Fl. 204. *Cucumis Melo* L., var. *Cantalupo* Ser. ex DC. Prodr. III, 300, et Fl. Jard. II, 500. Referable to *Cucumis Melo* L., race-group *Cantalupo*, var. *communis* Harz, loc. cit. 778.—R. 680; H. 110.—F. 402.

Figure reduced from Fuchs, Hist. 701.

110. *Colocynthis grandis candida*, 118 v., sine ic. *Colocynthis oblonga* C.B.P. 313 b. *Cucurbita Pepo* L., variety-group *citrullina* Alef. Landwirthsch. Fl. 219. Differs from no. 94 by the colour of the fruit, which is first green, then white with green blotches, and finally all white.

111. *Colocynthis fungosa et levis*, 118 v., sine ic. *Colocynthis* Annot. Diosc. 75 v. *Colocynthis fructu rotundo minor* C.B.P. 313 a. *Cucumis Colocynthis* L. Sp. 1011. *Citrullus Colocynthis* (L.) Schrad.—Regnault, Bot. I, 23; Köhler, Med. Pfl. I, t. 51; B.T. 114; P.C. 29; R. 676; Dalziel, Useful Pl. W. Trop. Afr. 53; H. 36.—F. 212; Tr. 828!

A figure of this, the true Colocynth, taken from Tragus, was placed opposite one of the false Colocynths—vide no. 98 B.

112. *Cucumis puniceus*, 118 v., ic. 119 r. *Balsamina rotundifolia reposita sive mas* C.B.P. 306 a; J. 114. *Momordica Balsamina* L. Sp. 1009.—Regnault, Bot. I, t. 22; R. 678; Dr. 648.—F. 105; Tr. 899!

*Liber II : De illis quarum historia a veteribus vel exacte  
tradita non est, vel omnino praeterita.*

113. *Ranunculus palustris*, 119 v., cum ic. ; Th. 99 ; Sch. 29. *Ranunculus palustris apii folio laevis* C.B.P. 180 a ; J. 59 ; S. 28. *Ranunculus fructu oblongo, foliis inferioribus palmatis, summis digitatis* Hall. Enum. 323. *Ranunculus sceleratus* L. Sp. 551.—Fl. Dan. iv, t. 571 ; R. 608 ; Dr. 230.—F. 88 ; Tr. 93 !

114. *Ranunculi secunda species vel Sardous Ranunculus*, 119 v., sine ic. *Ranunculus secundus* Camer. Epit. 381. *Ranunculus palustris apii folio lanuginosus* C.B.P. 180 a. *Ranunculus fructu oblongo, foliis inferioribus palmatis, summis digitatis* L. Hort. Cliff. 230. *Ranunculus sardous* Crantz, Stirp. Austr. fasc. ii, 84 (1763).—Hegi, Ill. Fl. III, 555, fig. 690, a-c ; R. 609.

115. *Ranunculi tertia species*, 120 r., cum ic. (caulis dextri tantum) ; Th. 96 ; Sch. 29. *Ranunculus nemorosus luteus* C.B.P. 178 a ; J. 58 ; S. 28 ; *Anemone semine levi, petalis quinis, subrotundis, luteis* Hall. Enum. 329. *Anemone ranunculoides* L. Sp. 541.—Fl. Dan. i, t. 140 ; Hegi, Ill. Fl. III, 520, t. 116, fig. 2 ; R. 604 ; Dr. 228.—F. 91 ; Tr. 95 !

116. *Ranunculi quarta species*, 120 r., cum ic. (caulis sinistri tantum). *Anemone nemorosa flore majore* C.B.P. 176 b ; J. 57 ; S. 27. *Anemone semine levi, petalis senis, ellipticis* Hall. Enum. 330. *Anemone nemorosa* L. Sp. 541.—Dietr. Fl. Boruss. III, t. 163 ; R. 603 ; Dr. 227.—Br. 136 : F. 90 ; Tr. 95 !

117. *Ranunculi quinta species*, 120 v., ic. 120 r. *Ranunculus arvensis*, 120 r. *Ranunculus arvensis echinatus* C.B.P. 179 b ; J. 58 ; S. 28. *Ranunculus seminibus aculeatis, foliis decompositis linearibus* Hall. Enum. 323. *Ranunculus arvensis* L. Sp. 555.—Dietr. Fl. Boruss. III, t. 182 ; R. 609 ; Dr. 230.—F. 86.

118. *Ranunculi sexta species, flammula*, 120 v., sine ic. Probably *Ranunculus polyanthemus* L. Sp. 554.—Dietr. Fl. Boruss. iv, t. 222 ; Zenker, Fl. Thüringen, iv, t. 453 ; Dr. 230.

Cordus stated that this species was called 'flammula' on account of its burning and biting taste, and that the leaves were broader than those of the preceding. This suggests *Ranunculus polyanthemus*, which, when fresh, will blister the skin (Dietr. loc. cit.). Erwin Schulze, Ind. Thal. 29, identified *Ranunculus Cordi sextus* Thal. Sylv. Hercyn. 99, as *R. lanuginosus* L., but that species does not appear to be acrid (Dietr. loc. cit. t. 287), and the leaves bear little resemblance to those of *R. arvensis*.

119. *Ranunculi septima species, coronaria*, 120 v. *Ranunculus multiplex*, ic. 120 v. *Ranunculus repens* L. Sp. 554, var. flore pleno Hort.

The comparison of the leaves to those of *Apium* suggests *Ranunculus repens* rather than *R. acris* L. The figure also may represent *R. repens*. It is adapted from Fuchs, Hist. 158, previously referred to *R. acris* var. flore pleno (Br. 48 ; F. 87).

120 A. *Ranunculi octava species*, 121 r., excl. ic. Probably *Ranunculus acris* L. Sp. 554. Cordus compared it to his *Ranunculi sexta species*, identified above as *R. polyanthemus* L., and *R. acris* resembles the latter in facies and properties.—R. 608.

120 B. *Ranunculi octava species*, 120 v., quoad ic. tantum. *Ranunculus hortensis primus* Dod. Pempt. 422 (1583). *Ranunculus polyanthemus primus Dodonaei* Th. 98; Sch. 29. *Ranunculus pratensis repens hirsutus* C.B.P. 179 a; J. 58; S. 28. *Ranunculus repens* L. Sp. 554.—Dietr. Fl. Boruss. III, t. 177; Syme, Engl. Bot. I, t. 34; R. 608; Dr. 230.—Tr. 94! *Polyanthemum simplex* Dod. Cruydeb. 457.

121. *Ranunculi nona species*, 121 r. *Ranunculus minor, flammula*, ic. 121 r. *Ranunculus bulbosus* Th. 96; Sch. 28. *Ranunculus pratensis radice verticilli modo rotunda* C.B.P. 179 a; J. 58; S. 28. *Ranunculus radice simplici subglobosa* Hall. Enum. 323. *Ranunculus bulbosus* L. Sp. 554.—Reichb. Ic. Fl. Germ. IV, t. 20, fig. 4611; R. 608; Dr. 230.—Br. 49; F. 89.

Figure adapted from Fuchs, Hist. 160.

122. *Ranunculi decima species*, 121 r., cum ic. *Pulsatilla folio crassiore et majore flore* C.B.P. 177 a; C. 310; J. 57; S. 28. *Anemone tubis caudatis, imis foliis duplicato pinnatis, multifidis, superioribus angustissimis* Hall. Enum. 333. *Anemone Pulsatilla* L. Sp. 539.—Fl. Dan. I, t. 153; Hegi, Ill. Fl. III, t. 116, fig. 5; P.C. 230; L.P. 156; R. 605.—Br. 76; F. 517; Tr. 413!

Referred by Dierbach (Beitr. Deutschl. Fl. I, 93: 1825) to *Anemone pratensis* L. It is probable that Cordus did not distinguish that species from *A. Pulsatilla*.

\*123. *Ranunculi undecima species*, 121 v., sine ic. *Anemone sylvestris alba major* C.B.P. 176 b; J. 57; S. 27. *Anemone sylvestris* L. Sp. 540: Dietr. Fl. Boruss. III, t. 165; R. 604; Dr. 228.

Described as like no. 116 (*Anemone nemorosa* L.), but with rougher (i.e. hirsute) stem and leaves, a larger flower, a white woolly head of seed the size of a hazel-nut, and slender roots. This clearly indicates *A. sylvestris*. Gesner suggested that the plant called Weyssé Bitzwurz, Grawmennle, or Gross Schneebluomen (i.e. *Anemone alpina* L.) might be the same. Haller, Enum. 331, referred *Ranunculi undecima species* Cord. to *Anemone tubis caudatis, foliis omnibus duplicato pinnatis, pinnulis remotis, albo flore*, which is also a synonym of *A. alpina*.

124. *Ranunculi duodecima species*, 121 v., cum ic. *Flammula Ranunculus* Dod. Purg. 292 (1574). *Ranunculus aquaticus minor* Th. 100; Sch. 29. *Ranunculus longifolius palustris minor* C.B.P. 180 b; J. 59; S. 28. *Ranunculus foliis ovato lanceolatis, petiolatis, caule declinato* Hall. Enum. 322. *Ranunculus Flammula* L. Sp. 548.—Dietr. Fl. Boruss. III, t. 180; R. 607.

Thalius (loc. cit. 99) referred this species to his *Ranunculus aquaticus major*

(i.e. *R. Lingua* L.), but the height of the plant ('cubitalis'), the suggestion that it should be called 'platyphyllos', and the comparison of the lower leaves to those of laurel indicate *R. Flammula*.

125. *Chelidonium minus*, 122 r., ic. 121 v.; Annot. Diosc. 49 r. *Chelidonia rotundifolia minor* C.B.P. 309 a; J. 115; S. 57. *Ficaria* Hall. Enum. 321. *Ranunculus Ficaria* L. Sp. 550.—Reichb. Ic. Fl. Germ. iv, t. 1, fig. 4572; P.C. 216; R. 609.—Br. 75; F. 494; Tr. 113!

126. *Chelidonium palustre*, 122 r., cum ic. *Caltha palustris flore simplici* C.B.P. 276 a; C. 725; J. 102; S. 51. *Populago* Hall. Enum. 319. *Caltha palustris* L. Sp. 558.—Reichb. Ic. Fl. Germ. iv, t. 101, fig. 4712; Bergeret, Phyt. Univ. II, 85; R. 610; Dr. 223.—Tr. 142!

\*127. *Chelidonia phragmitis, prima species*, 122 r., sine ic. *Fumaria bulbosa radice non cava minor* C.B.P. 144 b; J. 43. *Fumaria bulbosa* var. *intermedia* L. Sp. 699. *Fumaria intermedia* Ehrh. Beitr. vi, 146 (1791); Schkuhr, Bot. Handb. II, 319, t. 194. *Fumaria fabacea* Retz. (1795). *Corydalis intermedia* (Ehrh.) Mérat, Nouv. Fl. Paris, 272 (1812); Gaud. Fl. Helvet. iv, 437.—Dietr. Fl. Boruss. II, t. 108; R. 628; Dr. 251.

Distinguished from the following (*Corydalis cava*) by its solid corm, two diverging stems, and fewer flowers—characters diagnostic of *C. intermedia*.

128. *Chelidonia phragmitis, altera species*, 122 v., cum ic. *Fumaria bulbosa radice cava major* C.B.P. 143 b; C. 304; J. 43. *Fumaria caule simplici, bifolio, radice cava, foliis inter flores integris* Hall. Enum. 604. *Fumaria bulbosa* var. *cava* L. Sp. 699. *Fumaria cava* Mill. Gard. Diet. ed. 8, no. 7 (1768). *Corydalis cava* (Mill.) Schweigg. et Koerte.—Dietr. Fl. Boruss. II, t. 106; R. 627; Dr. 250.—Br. 9, 10; F. 50; Tr. 767!

\*129. *Sisyrinchion*, 122 v., sine ic. *Phalangium radice bulbosa stipulis maximis hirsutis, floribus umbellatis, petiolis multifloris* Hall. Hist. II, 102 (1768). *Ornithogalum arvense* Pers. in Usteri, Ann. Bot. XI, 8, t. 1, fig. 2 (1794). *Gagea arvensis* (Pers.) Schultes, Syst. VII, 547 (1829).—Dietr. Fl. Boruss. x, t. 680; R. 87; Dr. 123.

Described as having usually two roots (i.e. bulbs), root-leaves like those of *Crocus*, and hirsute cauline leaves. These characters and the habitat, in sandy fields, indicate *Gagea arvensis*.

130. *Petasites*, 123 r., cum ic.; Annot. Diosc. 70 r. *Petasites major et vulgaris* C.B.P. 197 a; C. 460; J. 67; S. 32. *Petasites floribus spicatis, flosculis omnibus androgynis* Hall. Enum. 706. *Tussilago Petasites* L. Sp. 866. *Petasites officinalis* Moench (1794). *Petasites hybridus* (L.) Gaertn. Mey. et Scherb. (1801).—Hayne, Arzn. Gewächse, II, t. 17; P.C. 46; R. 263.—F. 367; Tr. 415!

\*131 A. *Polygalon*, 123 v., excl. ic. *Polygala* Annot. Diosc. 72 v. *Astragaloides* Dod. Pempt. 541 (1583). *Glycyrrhiza sylvestris* Th. 54; Sch. 18.

*Orobus sylvaticus Viciae foliis* C.B.P. 352. *Orobus caule ramoso, foliis ovatis duodenis* Hall. Hist. 182. *Orobus niger* L. Sp. 729. *Lathyrus niger* (L.) Bernh. —Fl. Dan. vii, t. 1170; Dietr. Fl. Boruss. ix, t. 603; Hegi, Ill. Fl. iv, pars 3, 1572; R. 1009; Dr. 332.

Named *Glycyrrhiza sylvestris* by Aemylius (Georg Ömler) in a footnote. Erroneously identified by Gesner as *Foenograecum sylvestre* Trag. Hist. 599 (1552), which is *Astragalus glycyphyllos* L. Thalius, Sylv. Hereyn. 88, accepted this identification under his *Polygalon Cordi*, but mentioned that a different *Glycyrrhiza sylvestris* (described by him on p. 54) was common on the Harz Mountains and in many woods in Saxony and Thuringia. This is *Lathyrus niger* (L.) Bernh., as identified by Erwin Schulze. Ömler's *Glycyrrhiza sylvestris* was probably also *L. niger*.

The description given by Cordus cannot be reconciled with *Astragalus glycyphyllos*. Cordus stated that *Polygalon* had purple flowers becoming yellowish shortly before they dropped, whereas *A. glycyphyllos* has greenish-yellow flowers. Secondly, he described the axillary peduncles ('pediculi') as long: and this hardly applies to *A. glycyphyllos*. Thirdly, if Cordus had been describing *A. glycyphyllos*, it is inconceivable that he could have overlooked the false septum which is so marked a feature of the legume.

On the other hand, the description of *Polygalon* seems to agree with *Lathyrus niger*, as far as it goes. The one character which might appear to be inconsistent with a *Lathyrus*, namely, the imparipinnate leaf, actually confirms the identification. Cordus stated that there is generally an odd leaflet: in *Lathyrus niger* 40 out of 45 European specimens examined in the Kew Herbarium showed one or more leaves with an odd, pseudoterminal leaflet, though leaves with an even number of leaflets predominated. Gams in Hegi (loc. cit.) states that the rachis of the leaf of *L. niger* frequently ends in a leaflet. It is true that, when an odd leaflet is present, it lies in the same straight line as the rachis, but it actually represents one of the lateral leaflets of the distal pair, its nodal companion being suppressed. The leaf axis is morphologically terminated, as usual, by a small bristle, representing a terminal leaflet, but the odd lateral leaflet assumes the terminal position, the bristle being more or less divergent. Occasionally two bristles are found at the end of a leaf, the additional one representing a leaflet of the distal pair, being opposite to a normal foliaceous leaflet.

Cordus mentioned that the legumes of *Polygalon* resembled those of *Vicia* (*Vicia sativa*), and this is true of *L. niger*. He described the inflorescence in the phrase, 'coma purpureis floribus plena', which might suggest that it was many-flowered, whereas, according to Gams, the raceme of *L. niger* is 3-10-flowered. Compared with certain species of *Lathyrus* and *Vicia*, however, a well-developed inflorescence of *L. niger* might easily have been described as 'floribus plena' by Cordus.

*Polygalon* Cord. was identified with *Astragalus glycyphyllos* chiefly because of the description of the root as 'long, thick and sweet', and of the German

names 'wilde Süswurtz' and 'wilde Lakeritz' (wild Liquorice) cited by Cordus under *Polygala* Diosc. But, according to both Thalius and Haller, the root of *Lathyrus niger* is also 'long, thick and sweet'. Thalius called that species *Glycyrrhiza sylvestris* (wild Liquorice), and Nemnich (Allg. Polyglott.-Lex. d. Naturgeschichte, III, 798: 1794) gave 'falsche Süssholzstaude' as one of its German names.

Dierbach (Beitr. Deutschl. Fl. I, 80) referred *Polygalon* Cord. to *Astragalus Hypoglottis* L. (*A. danicus* Retz.), but the description, especially that of the pods, which are said to resemble those of *Vicia sativa*, cannot be reconciled with *Astragalus danicus*.

131 B. *Polygon*, 123 v., quoad ic. tantum. *Polygalon* Cordi Th. 88 (1588); Sch. 26. *Glycyrrhiza sylvestris floribus luteo pallescentibus* C.B.P. 353 a; J. 132; S. 66. *Astragalus caule ex alis spicato, ramoso, procumbente, foliis ovalibus* Hall. Enum. 565. *Astragalus glycyphyllos* L. Sp. 758.—Fl. Dan. VII, t. 1108; R. 1003; Dr. 323.—Tr. 599!

132. *Erucula maior*, 124 r., ic. 123 v. *Eruca* Gesn. in Annot. Diosc. 45 v. *Eruca latifolia alba, sativa Dioscoridis* C.B.P. 98 a; C. 213; S. 15. *Eruca* Hall. Enum. 553. *Brassica Eruca* L. Sp. 667. *Eruca sativa* Mill. Gard. Diet. ed. 8, no. 1 (1768); O. E. Schulz in Engl. Pflanzenr. IV, 105 (Crucif.-Brassic.), I, 181. *Eruca vesicaria* (L.) Thell.—Hegi, Ill. Fl. IV, pars 1, 200; Regnault, Bot. I, t. 144; L.P. 152; R. 644; H. 85.—Tr. 102!

\*133. *Gladiolus palustris*, 124 r., sine ic. *Juncus floridus major* C.B.P. 12 b. *Butomus* Hall. Enum. 299. *Butomus umbellatus* L. Sp. 372.—Fl. Dan. IV, t. 604; Kirchner, Loew, u. Schröter, Lebensgesch. Blütenpfl. Mitteleur. I, 653, fig. 384; R. 80; Dr. 76.

134. *Struthion*, 124 r., ic. 124 v. *Imperatoria major* C.B.P. 156 a; C. 306; J. 48; S. 23. *Imperatoria* Hall. Enum. 445. *Imperatoria Ostruthium* L. Sp. 259. *Peucedanum Ostruthium* (L.) Koch.—Plenck, Ic. Pl. Med. III, t. 211; Hayne, Arzn. Gewächse, VII, t. 15; Reichb. Ic. Fl. Germ. XXI, t. 123; P.C. 183; R. 546.—Br. 159; F. 436; Tr. 433!

135. *Lepidium maius sive Hiberis maior*, 124 v., cum ic.; Annot. Diosc. 48 v. *Lepidium latifolium* C.B.P. 97 a; C. 213; J. 27; S. 14. *Lepidium latifolium* L. Sp. 644.—Regnault, Bot. I, t. 133; Hegi, Ill. Fl. IV, pars 1, t. 126, fig. 4; R. 639; Dr. 252.—Br. 180; F. 274; Tr. 88!

136. *Polium maius*, 124 v., ic. 125 r.; Annot. Diosc. 58 r. *Polium Lavandulae folio* C.B.P. 220 a; C. 465; J. 78; S. 39. *Chamaedrys foliis integris angustis, ellipticis, subtus incanis* Hall. Enum. 632. *Teucrium montanum* L. Sp. 565.—Sibth. Fl. Graec. VI, t. 534; Hegi, Ill. Fl. V, pars 4, 2525, fig. 3364; R. 423; Dr. 569.

137. *Polium minus*, 125 r., sine ic. [*Polii*] *minor species* Annot. Diosc. 58 r. *Teucrium Polium* L. Sp. 566.—R. 423.

138. *Peucedanum*, 125 v., cum ic.; Annot. Diosc. 16 v. *Peucedanum Germanicum* C.B.P. 149 a; J. 45; S. 22. *Peucedanum officinale* L. Sp. 245.—Hayne, Arzn. Gewächse, VII, t. 4; Syme, Engl. Bot. IV, t. 609; R. 545; Dr. 497.—F. 340; Tr. 881!

139. *Chamaedrys*, 125 v., ic. 126 r. *Chamaedrys minor repens* C.B.P. 248 a. *Chamaedrys procumbens, foliis solidis, ovalis, rotunde crenatis* Hall. Enum. 630. *Teucrium Chamaedrys* L. Sp. 565 (cited under var.  $\beta$ ).—Hayne, Arzn. Gewächse, VIII, t. 4; Hegi, Ill. Fl. v, pars 4, t. 223, fig. 5; P.C. 115; L.P. 126; R. 422.—F. 495; Tr. 204!

140. *Lotus sativa*, 126 r., cum ic.; Annot. Diosc. 70 v. *Lotus sativa Cordi* Cam. Hort. Med. 91 (1588). *Lotus hortensis odora* C.B.P. 331 b; J. 123; S. 62. *Trifolium Melilotus caerulea* L. Sp. 764. *Melilotus caerulea* Lam. (1797). *Trigonella caerulea* (Lam.) Ser.—Regnault, Bot. II, t. 101; Reichb. Ic. Fl. Germ. XXII, t. 58; R. 991; Dr. 315.—F. 464; Tr. 588!

141. *Coriandrum*, 126 r., ic. 126 v.; Annot. Diosc. 54 v. *Coriandrum majus* C.B.P. 158 a; C. 307; J. 49; S. 24. *Coriandrum sativum* L. Sp. 256.—Plenck, Ic. Pl. Med. III, t. 204; Sibth. Fl. Graec. III, t. 283; Hayne, Arzn. Gewächse, VII, t. 13; B.T. 133; P.C. 81; L.P. 140; R. 558; H. 38.—Br. 70; F. 197; Tr. 115!

142. *Anisum*, 126 v., cum ic.; Annot. Diosc. 54 v. *Anisum herbariis* C.B.P. 159 a; J. 49; S. 24. *Pimpinella Anisum* L. Sp. 264.—Plenck, Ic. Pl. Med. III, t. 223; B.T. 122; P.C. 11; L.P. 135; R. 533; H. 5.—Br. 173; F. 35; Tr. 453!

143. *Ammi*, 127 r., cum ic.; Annot. Diosc. 54 v. *Ammi majus* C.B.P. 159 a; J. 49; S. 24. *Ammi majus* L. Sp. 243.—Plenck, Ic. Pl. Med. II, t. 181; Sibth. Fl. Graec. III, t. 273; Reichb. Ic. Fl. Germ. XXI, t. 22; R. 531; Dr. 488.—F. 38; Tr. 874!

144. *Dolichus, Smilax sativa sive laevis*, 127 r. *Phaseolus* 127 v., quoad ic. tantum. *Phaseolus aller* Annot. Diosc. 43 v. *Smilax hortensis sive Phasiolus major* C.B.P. 339 a; J. 126; S. 63. *Phaseolus vulgaris* L. Sp. 723.—Hayne, Arzn. Gewächse, XI, t. 46; Vilmorin-Andrieux & Cie, Les Plantes Potagères, ed. 3, 285; R. 1018; Dr. 335; H. 72.—F. 404; Tr. 615!

Cordus mentioned that *Dolichus* was a tall climber with somewhat rough stems and leaves ('habent claviculae et folia lenem asperitatem quandam'), numerous flowers, white, pale, yellow, or red, long pendent pods with a curved beak, 6–9 seeds the shape of a sheep's kidney, differing in colour in the different races, white, pale, yellow, blackish ('niger') or variegated ('vario colore'). These diagnostic characters and the remainder of the description are consistent with *Phaseolus vulgaris*. According to Vilmorin-Andrieux, some of the present-day races, e.g. the White Dutch bean (loc. cit. 292), climb to a height of over 10 feet, and all have roughish stems and leaves. The racemes are 2–8-flowered,



and pods with a curved beak are characteristic of the species. The seeds have exactly the shape of a sheep's kidney, and their number in a pod ranges from four to nine. Eight races may have as many as eight seeds in a pod, while one of these (the White Dutch bean) may have nine. Seeds of many different colours and markings occur in the different races (see Martens, G., 'Die Gartenbohnen', 1860, tt. 1-12).

145. *Phaseolus*, 127 v., excl. ic. *Phaseolus primus* Annot. Diosc. 43 v. *Dolichos unguiculatus* L. Sp. 725. *Dolichos sinensis* L. (1756). *Vigna sinensis* (L.) Savi ex Hassk. *Vigna unguiculata* (L.) Walp.; Fawc. et Rendle, Fl. Jam. iv, pars 2, 66.—Jacq. Hort. Vindob. I, tt. 23, 67, and III, t. 71; Bot. Mag. t. 2232; R. 1020; Dr. 337; H. 41.

Described by Cordus as a shorter plant than *Dolichus* (*Phaseolus vulgaris*), with smooth stems and leaves, peduncles 9 in. long arising near the base of the stem and others arising from the upper axils, white flowers, greenish outside, much larger than in *Dolichus*, with caducous petals, long dark terete pods, slenderer and more terete than those of *Dolichus*, without a beak, 7-14 white seeds with a dark ring around the place of attachment, rounder and smaller than in *Dolichus*. These characters point unmistakably to a variety of the Cow Pea or Calavance, *Vigna unguiculata*, which was the *Dolichos* of ancient Greece and the *Phaselus* or *Phaseolus* of ancient Rome.

146. *Nigella cornuta sive sylvestris*, 128 r., sine ic. *Nigella cornuta*, ic. 127 v. *Cyminum sylvestre alterum* Annot. Diosc. 54 b. *Nigella arvensis cornuta* C.B.P. 145 a; C. 304; J. 43; S. 21. *Nigella flore foliis nudo, pistillis corollam aequantibus* Hall. Enum. 316. *Nigella arvensis* L. Sp. 534.—Hayne, Arzn. Gewächse, vi, t. 17; Reichb. Ic. Fl. Germ. iv, t. 120, fig. 4735; Hegi, Ill. Fl. III, t. 112, fig. 2; R. 613; Dr. 223.—F. 287.

147. *Nigella*, 128 r., excl. ic.; Annot. Diosc. 56 v. *Nigella flore minore simplici candido* C.B.P. 145 b; J. 44; S. 21. *Nigella sativa* L. Sp. 534.—Hayne, Arzn. Gewächse, vi, t. 16; Reichb. Ic. Fl. Germ. iv, t. 120, fig. 4736; R. 613; Dr. 222; H. 44.—F. 285.

148. *Nigella Damascena*, 128 r., cum ic. sub nomine *Nigella*. *Nigella angustifolia flore majore simplici caeruleo* C.B.P. 145 a; C. 304; J. 44; S. 21. *Nigella damascena* L. Sp. 534.—Hayne, Arzn. Gewächse, vi, t. 15; Reichb. Ic. Fl. Germ. iv, t. 120, fig. 4737; R. 613; Dr. 222.—F. 286; Tr. 117!

149. *Asclepias*, 128 v., cum ic. *Asclepias albo flore: et Gerar.* C.B.P. 303 a; C. 730; J. 113; S. 56. *Asclepias foliis ex ovato lanceolatis glabris, floribus racemosis albis* Hall. Enum. 525. *Asclepias Vincetoxicum* L. Sp. 216. *Vincetoxicum officinale* Moench (1794).—Regnault, Bot. I, t. 16; Svensk Bot. iv, t. 249; L.P. 77; R. 378.—Br. 106; F. 71; Tr. 180!

150. *Orchis, sive Testiculus maior*, 129 r. *Orchis maior*, ic. 128 v. *Orchis radicibus subrotundis, brachiolis labelli brevioribus, spinula ex divisione medii trunculi eminente* Hall. Enum. 262. *Orchis militaris* L. Sp. 941; Martens u.

Kemmler, Fl. Württ. u. Hohenz. ed. 2, 568.—Dietr. Fl. Boruss. I, t. 63 ; Hegi, Ill. Fl. II, t. 72, fig. 4 ; Nelson, Orch. Deutschl. t. 6, fig. 16 ; R. 124 ; Dr. 149.—Br. 29 ; F. 313 ; Tr. 778 !

The description is consistent with *Orchis militaris*. The size of the plant, one foot or more in height, sometimes less, points to that species, which is distributed in mountain meadows throughout Württemberg and Hohenzollern, rather than to *O. purpurea* Huds., which is  $1\frac{1}{2}$ – $2\frac{1}{2}$  ft. high and is less common there according to Martens and Kemmler (loc. cit.).

Cordus mentions a second kind, differing only in having yellowish-white flowers. This was probably the white-flowered form with yellowish hairs on the labellum, recorded by Martens and Kemmler.

151 A. *Orchis, sive Testiculus minor*, 129 r., excl. ic. *Orchis radicibus subrotundis, calcare nullo, labello holosericeo, vario, latissimo, integro, mucronem ex medio demittente* Hall. Enum. 268, partim. *Ophrys apifera* Huds.—Nelson, Orch. Deutschl. t. 2, fig. 4 ; R. 126 ; Dr. 150.—F. 318.

The number of flowers (5–8) and the purple colour of the sepals point to *O. apifera*, rather than to *O. fuciflora*, although Cordus may have included both species under his *Testiculus minor*. According to Martens and Kemmler (loc. cit.), *O. apifera* has 3–10 flowers and *O. fuciflora* 3–6 flowers. The two species seem to be equally common in Württemberg and Hohenzollern. The habitat 'Nascitur editis, siccisque campis' suggests *O. fuciflora* (*O. arachnites*), which Martens and Kemmler record from 'Bergwiesen' as well as from 'Waldwiesen'.

151 B. *Orchis minor*, 129 r., quoad ic. tantum. *Orchis fucum referens major foliolis superioribus candidis et purpurascens* C.B.P. 83 a. *Orchis radicibus subrotundis, calcare nullo, labello holosericeo, vario, latissimo, integro, mucronem ex medio demittente* Hall. Enum. 268, partim. *Orchis larvatus seu personatus femina foliis tribus superioribus ex fusco albicantibus* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. II, 24, t. 18, no. 68 (1770). *Ophrys insectifera*, var.  $\iota$ , L. Sp. ed. 2, 1343. *Orchis fuciflora* Crantz (1769). *Ophrys fuciflora* (Crantz) Reichb.—Nelson, Orch. Deutschl. t. 2, fig. 3 ; R. 126 ; Dr. 150.—Br. 31 ; Tr. 783 !

152 A. *Testiculus alius*, 129 r., excl. ic. duabus Tragi 129 v. *Orchis morio foemina* C.B.P. 82 a. *Orchis radicibus subrotundis, cucullo clauso, lineato, labello ampliter trifido, crenato* Hall. Enum. 266. *Orchis morio* L. Sp. 940.—Hegi, Ill. Fl. II, t. 71, fig. 1 ; Nelson, Orch. Deutschl. t. 10, fig. 28 ; R. 123 ; Dr. 148.—Br. 30 ; F. 317.

152 B. [*Cynosorchis nostra mas quarto* Trag.] 129 v., ic. sinistra.—Tr. 779 !—Probably *Orchis militaris* L.

152 C. [*Satyrion primum Dioscoridis* Trag.] 129 v. ic. dextra.—Tr. 780, ic. sinistra !—Probably *Orchis militaris* L., the lobing of the labellum being inconsistent with *O. simia* Lam., to which there is a strong resemblance in general habit.

153 A. *Testiculus candidus odoratus maior*, 129 v., excl. ic. sinistra, 130 r. *Orchis trifolia major* C.B.P. 83 a. *Orchis radicibus conicis, labello lingulato, simplicissimo* Hall. Enum. 266, partim. *Orchis bifolia* L. Sp. 939. *Platanthera bifolia* (L.) Rich.—Engl. Bot. ix, t. 1463 ; Nelson, Orch. Deutschl. t. 13, fig. 40 ; R. 125.—F. 405.

Cordus described the flowers as sweet-smelling, a character which indicates *Platanthera bifolia*. In his *Testiculus bifolius* (no. 230), on the other hand, the scent of the flowers was not mentioned. It evidently corresponds to *P. chlorantha* (Custer) Reichb.

153 B. *Testiculus candidus*, 130 r., ic. tantum. *Gymnadenia conopsea* (L.) R. Br.—Nelson, Orch. Deutschl. t. 14, fig. 44 ; R. 125.—F. 406 : Tr. 782 ! (*Orchis quinta odorata*).

The description of the flowers, given by Tragus, as purple, unspotted and extremely sweet with a smell resembling that of cloves, points to *Gymnadenia conopsea*. The figure agrees with that species, except for the tubers which appear, as in certain other cases, to have been added from imagination.

154 A. *Testiculus pumilio*, 130 r.—No description extant.

154 B. *Testiculus pumilio* Gesn., 130 r., ic. dextra. *Orchis oblongus vel duplex* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. ii, 10, t. 17, no. 58 (1770). *Spiranthes aestivalis* (Lam.) Rich.—Nelson, Orch. Deutschl. t. 16, fig. 50.—*Satyrium exiguum*, das vii. und kleinst Satyrium, Tr. 784 !

The figures illustrating the seventh *Satyrium* of Tragus seem to have been drawn from specimens of *Spiranthes aestivalis*, judging from the narrow leaves and more or less secund flowers. The tubers may have been added from imagination. From his remarks as to time of flowering it is evident that Tragus (Stirp. II, 782) included both *Spiranthes aestivalis* and *S. spiralis* (L.) K. Koch under his seventh *Satyrium*.

155. *Testiculus candidus odoratus minor*, 130 r., sine ic. *Triorchis alba odorata minor* C.B.P. 84 b : J. 24 ; S. 13. *Helleborine radicibus conicis simplicibus* Hall. Enum. 274, partim. *Ophrys spiralis* L. Sp. 945. *Spiranthes spiralis* (L.) K. Koch.—Nelson, Orch. Deutschl. t. 16, fig. 49 ; R. 126 ; Dr. 150.—Br. 32.

The description of the inflorescence clearly indicates *Spiranthes spiralis* : " coliculus . . . a media sui parte usque ad cacumen continua, minimorum candidorumque florum, . . . serie circumvolutus."

156. *Palma Christi, prima species*, 130 v., cum ic. sinistra. *Orchis* no. 28, var.  $\beta$ , Hall. Enum. 273. *Orchis maculata* L. Sp. 942.—Nelson, Orch. Deutschl. t. 8, fig. 21 ; P.C. 244 ; R. 124 ; H. 173.—F. 407 : Tr. 781 ! (*Orchis foemina altera*).

157. *Palma Christi, altera species*, 130 v., sine ic.—Description insufficient to determine the species.

158. *Palma Christi*, *tertia species*, 130 v., sine ic. *Orchis palmata angustifolia purpurea maculata* Hall. Enum. 273, partim.

Probably *Orchis latifolia* L. (*O. incarnata* L.); Nelson, Orch. Deutschl. t. 5, figs. 11, 12; R. 124; Dr. 149. The height of the plant (1½ feet), the hyacinth-like leaves, and the colour of the flowers—"interdum violaceos, nonnunquam etiam candidos"—suggest this species. The occasional plants with spotted leaves ("folia . . . raro purpureis punctis distincta") may have been hybrids.

159 A. *Palma Christi alia*, 130 v., excl. ic.—possibly *Orchis Traunsteineri* Saut., or, alternatively, a form of *O. latifolia* L. (*O. incarnata* L.).

159 B. *Palma Christi alia*, 130 v., quoad ic. tantum. *Orchis radicebus palmatis, calcare ovario longiore, labello aequaliter trifido, unicolore* Hall. Enum. 271. *Gymnadenia conopsea* (L.) R. Br.—Nelson, Orch. Deutschl. t. 14, fig. 44; R. 125.—F. 406; Tr. 780! (*Orchis foemina*).

160. *Symphytum sylvestre*, 131 r., cum ic. sub nomine *Pulmonaria Plinii* Gesn. *Pulmonaria foliis radicalibus ovato cordatis* Hall. Enum. 516, var. β, foliis absque maculis. *Pulmonaria officinalis* L. Sp. 135, subsp. *obscura* (Dum.) Murb.; Hegi, Ill. Fl. v, pt. 3, 2215.—Dietr. Fl. Boruss. iv, t. 245; L.P. 205; R. 436.

Cordus describes the radical leaves as cordate at the base, "juxta pediculum lata et figura hederacea", a character of *P. officinalis*.

161. *Papaver cornutum*, 131 r., ic. 131 v.; Annot. Diosc. 66 v. *Papaver corniculatum luteum* C.B.P. 171 b; C. 309; J. 55; S. 27. *Glaucium foliis tomentosis, imis pinnatis, superioribus serratis, amplexicaulibus* Hall. Enum. 304. *Chelidonium Glaucium* L. Sp. 506. *Glaucium flavum* Crantz.—Curtis, Fl. Lond. ed. 2, iv, t. 46 (K. 63); R. 626; Dr. 248.—F. 295; Tr. 123!

"Seritur apud nos in hortis: in calidioribus vero regionibus sponte in asperis maritimis exit."

162. *Cyclaminus*, 131 v., ic. 132 r.; Annot. Diosc. 48 r. *Cyclamen orbiculato folio inferne purpurascens* C.B.P. 308 a; C. 731; J. 114; S. 57. *Cyclamen* Hall. Enum. 499. *Cyclamen europaeum* L. Sp. 145.—Jacq. Fl. Austr. v, 401; R. 500; Dr. 513.—F. 255; Tr. 906!

163. *Gentiana*, 132 r., cum ic.; Annot. Diosc. 49 v. *Gentiana major lutea* C.B.P. 187 a; C. 310; J. 62; S. 30. *Gentiana floribus rotatis, verticillatis* Hall. Enum. 479. *Gentiana lutea* L. Sp. 227.—Hayne, Arzn. Gewächse, XIII, t. 28; B.T. 182; P.C. 114; L.P. 114; B.P.C. 482; R. 385; H. 64.—F. 411; Tr. 174!

164 A. *Sison sive Sison*, 132 v., cum ic.; Annot. Diosc. 54 r. *Sison quod Amomum officinis nostris* C.B.P. 154 a; S. 23. *Sison Amomum* L. Sp. 252.—Jacq. Hort. Vindob. III, t. 17; R. 531; Dr. 489.—F. 373; Tr. 461!

"Seritur apud nos in hortis."

164 B. [*Apium sylvestre* Dod.], 133 r., ic. sinistra. *Apium sylvestre lacteo succo turgens* C.B.P. 153 b; C. 306; J. 47. *Selinum sylvestre* L. Sp. 244. *Selinum palustre* L. Sp. 244. *Peucedanum palustre* (L.) Moench.—Jacq. Fl. Austr. II, 33, t. 152; Svensk Bot. VI, t. 380; Reichb. Ic. Fl. Germ. XXI, t. 1966; R. 546; Dr. 499.—*Apium sylvestre* Dod. Cruydeb. 650 (1554).

This species is described by Cordus (Hist. 149 r.) under the name *Olsenichium*—vide no. 224.

165. *Iris nostras sativa*, 132 v., ic. 133 r. *Iris nostra* Annot. Diosc. 1 r. *Iris hortensis latifolia* C.B.P. 31 a. *Iris germanica* L. Sp. 38.—Sibth. Fl. Graec. I, t. 40; Hayne, Arzn. Gewächse, XII, t. 2; Hegi, Ill. Fl. II, t. 66, fig. 1; L.P. 22; Dr. 137; B.P.C. 561; R. 109; H. 128.—F. 180; Tr. 703!

“Apud nos in hortis, vineis ac murorum coronis seritur.”

\*166. *Iris sylvestris*, 133 v., sine ic. *Iris corollis barbatis, caule foliis longiore, multiflora* Hall. Enum. 280. *Iris aphylla* L. Sp. 38; Dykes, The genus *Iris*, 165, obs. (1913); Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. XXXIII, 51 (1916).—Reichb. Ic. Fl. Germ. IX, tt. 331–333.

167. *Xiris*, 133 v., cum ic. *Gladiolus foetidus* C.B.P. 30 a. *Iris foetidissima* L. Sp. 39.—Plenck, Ic. Pl. Med. I, 37; Hayne, Arzn. Gewächse, XII, t. 5; P.C. 117; R. 109.—F. 452; Tr. 904.

\*168. *Iris tenuifolia*, 133 v., sine ic. *Iris pratensis angustifolia humilior* C. Bauh. Cat. Pl. Bas. 19; Theatr. 598; Hall. Enum. 281. *Iris sibirica* L. Sp. 39.—Reichb. Ic. Fl. Germ. IX, t. 341; R. 110; Dr. 138.

Described by Cordus as slenderer than *I. germanica*, *aphylla*, and *foetidissima*, with leaves 9–12 inches long, never more than  $\frac{1}{2}$  inch broad, arising from a densely tufted rhizome clothed with the remains of old leaves. These characters, and the habitat: “in apricis planisque pratis, et frutetosis ac humentibus campis”, point to *I. sibirica*.

169. *Iris lutea sive Pseudacorus*, 134 r., cum ic. *Acorus adulterinus* C.B.P. 34 a. *Iris imberbis, lutea, nervo folii eminente* Hall. Enum. 281. *Iris Pseudacorus* L. Sp. 38.—Fl. Dan. III, t. 494; P.C. 310; L.P. 22; R. 109.—Br. 113; F. 6; Tr. 699!

170. *Filix latifolia*, 134 v., ic. 134 r. *Filix ramosa non dentata florida* C.B.P. 357 b; J. 133; S. 67. *Osmunda regalis* L. Sp. 1065.—Fl. Dan. II, t. 217; Curt. Fl. Lond. ed. 2, v, t. 150 (K. 7); R. 48; Dr. 60.—Tr. 543!

171 A. *Buglossa longifolia*, 134 v., excl. ic. 135 r. *Buglossum angustifolium majus* C.B.P. 256 a, partim; C. 473; S. 46. *Anchusa officinalis* L. Sp. 133.—Plenck, Ic. Pl. Med. I, t. 79; Hayne, Arzn. Gewächse, I, t. 25; L.P. 69; R. 437; Dr. 562.—Br. 35; F. 195.

Cordus describes the flowers as being small and purple, and states that the plant occurs spontaneously besides being grown in gardens. These points indicate *A. officinalis*, not *A. azurea* Mill.

171 B. *Buglossa longifolia*, 135 r., quoad ic. tantum. *Anchusa azurea* Mill. (*A. italica* Retz.).—Trew, Pl. Rar. t. 18 : R. 437.—F. 196; *Buglossa italica* Trag. Stirp. 232 !

\*172. *Argemone*, 135 r., sine ic. ; Annot. Diosc. 48 v. *Papaver dubium* L. Sp. 1196, var. *Lecoquii* (Lamotte) Fedde.—Jord. et Fourr. Ic. Fl. Eur. t. 7 ; Dr. 250.

The long capsule indicates *P. dubium*, and the yellow latex the variety *Lecoquii*.

173. *Paeonia foemina*, 135 r., ic. 135 v. ; Annot. Diosc. 60 r. *Paeonia communis vel foemina* C.B.P. 323 a ; J. 119. *Paeonia foliis difformiter lobatis* Hall. Enum. 311. *Paeonia officinalis* var. *feminea* L. Sp. 530. *Paeonia officinalis* L. em. Willd. (1800).—*Paeonia peregrina* Mill. secundum Huth in Engl. Jahrb. xiv, 270. *Paeonia foeminea* Mill. (1768) ; Hegi, Ill. Fl. iii, 456. —Hayne, Arzn. Gewächse, v, t. 26 ; Reichb. Ic. Fl. Germ. iv, t. 123 ; P.C. 212 ; L.P. 174 ; R. 619.—F. 112 ; Tr. 581 !

174. *Thymus nostras*, 135 v., ic. 136 r. *Thymus* Annot. Diosc. 52 v. *Thymus vulgaris folio tenuiore* C.B.P. 219 a ; J. 77 ; S. 38. *Thymus vulgaris* L. Sp. 591.—Hayne, Arzn. Gewächse, xi, t. 2 ; B.T. 205 ; P.C. 281 ; L.P. 146 ; B.P.C. 748 ; R. 409 ; H. 214.—Br. 266 ; F. 471 ; Tr. 43 !

175. *Thymus capitatus*, 136 r., sine ic. *Thymus aromaticus* Annot. Diosc. 52 v. *Thymus capitatus, qui Dioscoridis* C.B.P. 219 b ; J. 77 ; S. 38. *Satureja capitata* L. Sp. 568. *Coridothymus capitatus* (L.) Reichb. f.—Sibth. Fl. Graec. vi, t. 544 ; R. 410 ; Dr. 582.

176. *Achillea*, 136 r., ic. 136 v. *Achilleia* Annot. Diosc. 63 v. *Tanacetum minus album odore Camphorae* C. Bauh. Cat. Pl. Basil. 40 ; C.B.P. 132 a, partim ; C. 301 ; J. 38. *Achillea pinnis foliorum et pinnulis remotis, et angustis pinnulis plurimis* Hall. Enum. 715. *Achillea nobilis* L. Sp. 899 ; Mart. u. Kemmler, Fl. Württ. u. Hohenz., ed. 2, 285.—Dietr. Fl. Boruss. xi, t. 775 ; R. 281 ; Dr. 674.—*Nobile Millefolium* Trag. Stirp. 476 !

177. *Ruta sativa maior sive latifolia*, 136 v., cum ic. *Ruta* Annot. Diosc. 53 r. *Ruta hortensis latifolia* C.B.P. 336 a ; C. 737 ; J. 126 ; S. 63. *Ruta graveolens* L. Sp. 383, var.  $\gamma$ . *Ruta graveolens vulgaris* Alef. Landwirthsch. Fl. 106. *Ruta graveolens* L. subsp. *hortensis* (Mill.) Gams in Hegi, Ill. Fl. v, pars I, 70.—Regnault, Bot. ii, t. 15 ; Hayne, Arzn. Gewächse, vi, t. 8 ; B.T. 44 ; P.C. 241 ; L.P. 183 ; R. 883 ; H. 169.—Br. 162 ; F. 350 ; Tr. 68 !

\*178. *Ruta sativa tenuifolia*, 137 r., sine ic. *Ruta montana* Clus. Hist. ii, 136 (1601). *Ruta sylvestris minor* C.B.P. 336 b ; C. 737 ; J. 126. *Ruta graveolens* var. *montana* L. Sp. 383 ; Alef. Landwirthsch. Fl. 107. *Ruta montana* (L.) Mill.—Reichb. Ic. Fl. Germ. v, t. 154 ; R. 884.

Referred by Dierbach, Beitr. Deutschl. Fl. i, 45 (1825), to *Ruta angustifolia* Pers., which is distinguished by ciliate petals, a character which Valerius Cordus could not have failed to notice.

179. *Lupinus sativus*, 137 r., cum ic. *Lupinus* Annot. Diosc. 43 v. *Lupinus sativus flore albo* C.B.P. 347 a ; S. 65. *Lupinus albus* L. Sp. 721 ; Hegi, Ill. Fl. iv, pars 3, 1151, 1153.—Plenck, Ic. Pl. Med. vi, t. 552 ; R. 983 ; Dr. 310.—F. 175 ; Tr. 322 !

180. *Coronopus sativa*, 137 v., cum ic. *Coronopus* Annot. Diosc. 45 r. *Coronopus hortensis* C.B.P. 190 a ; C. 312 ; J. 64 ; S. 31. *Plantago Coronopus* L. Sp. 115.—Syme, Engl. Bot. vii, t. 1168 ; Hegi, Ill. Fl. vi, pars 1, 188, fig. 106 ; R. 250 ; Dr. 619.—F. 254 ; Tr. 99 !

181. *Rhodia radix*, 137 v., cum ic. ; Annot. Diosc. 64 v. *Rhodia radix* C.B.P. 286 a ; J. 108 ; S. 54. *Rosea Rivini et officinarum* Rupp. Fl. Jen. 81 (1718). *Rhodiola Rosea* L. Sp. 1035. *Sedum roseum* Scop. *Sedum Rhodiola* DC. *Sedum Rosea* (L.) Scop. corr. Sprague.—Fl. Dan. ii, t. 183 ; DC. Pl. Grasses, tt. 143, 143\* ; Journ. R. Hort. Soc. XLVI, 29, fig. 4 ; R. 575.—F. 378 ; Tr. 913 !

182. *Tordylon sive Seseli Creticum*, 138 r., cum ic. ; Annot. Diosc. 54 r. *Meum foliis anethi* C.B.P. 148 a ; C. 305 ; J. 44 ; S. 21. *Meum* Hall. Enum. 426. *Athamanta Meum* L. Sp. 245. *Meum athamanticum* Jacq.—Fl. Dan., Suppl. t. 132 ; R. 539 ; Dr. 493.—Br. 274 ; F. 130 ; Tr. 445 !

Dierbach (Beitr. Deutschl. Fl. i, 119 : 1825), misled by the name *Seseli creticum*, identified this with *Athamanta cretensis* L. The description of the leaves as having short capillary segments and the habitat in moist meadows indicate *Meum athamanticum* and are inconsistent with *Athamanta cretensis*.

183. *Ligusticum sativum*, 138 v., cum ic. *Ligusticum* Annot. Diosc. 54 r. *Ligusticum vulgare* C.B.P. 157 b ; J. 49 ; S. 24. *Ligusticum Levisticum* L. Sp. 250. *Levisticum officinale* Koch.—Hayne, Arzn. Gewächse, vii, t. 6 ; Dietr. Fl. Boruss. xi, t. 755 ; P.C. 173 ; L.P. 141 ; R. 540.—Br. 177 ; F. 435 ; Tr. 426 !

184. *Stratiotes terrestris maior sive Millefolium terrestre maius*, 139 r., cum ic. *Millefolius Stratiotes* Annot. Diosc. 70 r. *Millefolium vulgare album* C.B.P. 140 a ; C. 303 ; J. 41 ; S. 20. *Achillea pinnis foliorum plurimis, longe aequalibus, pinnatis, pinnulis trifidis et quinquefidis* Hall. Enum. 715. *Achillea Millefolium* L. Sp. 899.—Hayne, Arzn. Gewächse, ix, t. 45 ; Dietr. Fl. Boruss. vii, t. 504 ; B.T. t. 153 ; P.C. 309 ; L.P. 106 ; R. 280 ; H. 261.—Br. 204 ; F. 415 ; Tr. 477 !

185. *Stratiotes terrestris minor sive Millefolium terrestre minus*, 139 r., sine ic. *Achillea Millefolium* L. Sp. 899, forma.

Described as similar in all respects to the preceding, but much smaller and slenderer, rarely exceeding 9 inches in height, with very finely cut foliage, with a more acrid and strongly aromatic smell, and a much more acrid and bitter taste. Habitat : " in apricis tumulis ex pingui terra congestis, et in pinguium editorumque arborum marginibus, iisdem diu non cultis provenit."

186. *Hemerocallis rubens sive Lilium sylvestre*, 139 v., cum ic. *Hemerocallis* Annot. Diosc. 58 v. *Lilium floribus reflexis montanum* C.B.P. 77 b ; C. 211 ; J. 22 ; S. 12. *Lilium foliis verticillatis, floribus reflexis, corollis revolutis* Hall. Enum. 289. *Lilium Martagon* L. Sp. 303.—Jacq. Fl. Austr. iv, t. 351 ; Hayne, Arzn. Gewächse, viii, t. 28 ; R. 87 ; Dr. 121.—Br. 149 ; F. 63 ; Tr. 787 !

187 A. *Sonchus sylvestris*, 139 v., excl. ic. sub nomine *Lactuca sylvatica*, 140 r.—According to August Schulz in Mitt. Thüring. Bot. Ver. N.F. xxxiii, 65 (1916), this may possibly be *Lactuca quercina* L. ; Dietr. Fl. Boruss. xi, t. 741 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxx, t. 3212 ; R. 310 ; Dr. 691. The description is insufficient to identify the species with certainty. Dierbach (Beitr. Deutschl. Fl. ii, 72 : 1828) referred it to *Lactuca muralis* (L.) Fresen. ; Dietr. Fl. Boruss. x, t. 665.

\*187 B. *Lactuca sylvatica* Gesn. 140 r., ic. tantum. *Lactuca montana purpureocaerulea major* C.B.P. 123 b ; C. 297 ; J. 32 ; S. 16. *Prenanthes flosculus quinis, foliis lanceolatis denticulatis* Hall. Enum. 754. *Prenanthes purpurea* L. Sp. 797.—Jacq. Fl. Austr. iv, t. 317 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxx, t. 3205.

188 A. *Aster Atticus*, 140 r., excl. ic. ; Annot. Diosc. 71 r. *Aster atticus caeruleus vulgaris* C.B.P. 267 a ; C. 723 ; J. 98 ; S. 49. *Aster foliis scabris, ellipticis integris, floribus in summo caule umbellatis, coeruleis* Hall. Enum. 726. *Aster Amellus* L. Sp. 873.—Jacq. Fl. Austr. v, t. 425 ; Dietr. Fl. Boruss. ix, t. 631 ; R. 264 ; Dr. 663.—F. 73 ; Tr. 154.

188 B. *Aster Atticus*, 140 r., quoad ic. tantum. (*Chrysanthemon* Annot. Diosc. 60 r., cap. 156. *Bupthalmum Dioscoridis* C.B.P. 134 b ; C. 301 ; J. 39 ; S. 19. *Bupthalmum, Tanacetum minoris foliis* C.B.P. ed. 2, 134 b. *Anthemis tinctoria* L. Sp. 896.—Regnault, Bot. ii, t. 156 ; Dietr. Fl. Boruss. ix, t. 641 ; R. 279 ; Dr. 675.—F. 14 ; Tr. 152 !

\*189. *Oxycoccum*, 140 v., cum ic. ; Th. 82 ; Sch. 422. *Vitis Idaea palustris* C.B.P. 471 a ; C. 747 ; J. 155. *Oxycoccus* Hall. Enum. 413. *Vaccinium Oxycoccus* L. Sp. 351. *Oxycoccus quadripetalus* Gilib. (1781).—*Oxycoccus palustris* Pers. (1805).—Dreves et Hayne, Choix Pl. Eur. iv, t. 14 ; Dietr. Fl. Boruss. ii, t. 119 ; R. 518 ; Dr. 510 ; H. 42.

190. *Ricinus*, 141 r., ic. 140 v., ; Annot. Diosc. 74 r. *Ricinus vulgaris* C.B.P. 432 a ; J. 148. *Ricinus communis* L. Sp. 1007.—Regnault, Bot. iii, t. 28 ; Hayne, Arzn. Gewächse, x, t. 48 ; B.T. 237 ; P.C. 59 ; R. 831 ; H. 25.—Br. 280 ; F. 194 ; Tr. 288 !

191. *Cucumis anguinus sive asininus*, 141 r., ic. 141 v. *Cucumer agrestis* Annot. Diosc. 73 v. *Cucumis sylvestris asininus dictus* C.B.P. 314 a ; J. 115 ; S. 57. *Momordica Elaterium* L. Sp. 1010. *Ecballium Elaterium* (L.) A. Rich.—Regnault, Bot. i, t. 24 ; Hayne, Arzn. Gewächse, viii, t. 45 ; B.T. 115 ; L.P. 8 ; R. 676 ; H. 55.—F. 403 ; Tr. 832 !



192. *Cichorium sive agreste Intybum*, 141 v., cum ic. *Sylvestre Intybum* Annot. Diosc. 45 r. *Cichorium sylvestre sive Officinarium* C.B.P. 125 b ; C. 298 ; J. 33 ; S. 16. *Cichorium foliis pinnatis, pinnis triangularibus dentatis* Hall. Enum. 761. *Cichorium Intybus* L. Sp. 813.—Plenck, Ic. Pl. Med. vi, t. 586 ; Hayne, Arzn. Gewächse, II, t. 24 ; P.C. 68 ; L.P. 119 ; R. 306 ; H. 30.—Br. 168 ; F. 387 ; Tr. 272 !

193. *Cichorium sativum sive Endivia hortensis*, 142 r., cum ic. *Sativum Intybum* Annot. Diosc. 45 r. *Intybus sativa latifolia sive Endivia vulgaris* C.B.P. 125 a ; J. 33 ; S. 16. *Cichorium Endivia* L. Sp. 813. *Cichorium Endivia hyemale* Alef. Landwirthsch. Fl. 183.—Regnault, Bot. II, t. 144 ; R. 306 ; Dr. 694.—F. 386 ; Tr. 273 !

“Seritur acetariorum causa in hortis Italiae frequentius quam Germaniae.”

194. *Helenium maius sive Inula*, 142 v., ic. 142 r. *Helenium* Annot. Diosc. 9 v. *Helenium vulgare* C.B.P. 276 a ; C. 725 ; J. 102 ; S. 51. *Aster foliis amplexicaulibus, ex ovatis acuminatis, ora serrata, flore amplissimo luteo* Hall. Enum. 727. *Inula Helenium* L. Sp. 881.—Sibth. Fl. Graec. ix, t. 873 ; Plenck, Ic. Pl. Med. vii, t. 624 ; P.C. 97 ; L.P. 196 ; R. 269 ; H. 56.—Br. 170 ; F. 136 ; Tr. 170 !

195. *Chondrilla tenera*, 142 v., sine ic. *Chondrilla prima* Annot. Diosc. 45 r. *Chondrilla caerulea altera, Cichorii sylvestris foliis* C.B.P. 130 b ; C. 300 ; J. 37 ; S. 18. *Lactuca foliis glaucis, non spinosis, pinnatis, pinnis longis, saepe dentatis* Hall. Enum. 756. *Lactuca perennis* L. Sp. 796.—Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxx, t. 3213 ; Hegi, Ill. Fl. vi, pars 2, t. 277, fig. 5 ; R. 310.

196. *Milium (vel Panicum) Indicum*, 142 v., ic. 143 r. *Milium arundinaceum subrotundo semine, Sorgo nominatum* C.B.P. 26. *Holcus Sorghum* L. Sp. 1047, partim. *Holcus bicolor* L. Mant. II, 301. *Sorghum bicolor* (L.) Moench ; Snowden, The Cultivated Races of Sorghum, 106 (1936).—Besl. Hort. Eyvst., Pl. Autumn., Ord. 2, fol. 13 ; Host, Ic. Gram. Austr. iv, t. 2 ; R. 72 ; Dr. 80.—F. 440 ; Tr. 660 !

197 A. *Allium campestre*, 143 r., cum ic. sinistra sub eodem nomine. *Ampeloprasum* Annot. Diosc. 46 r. *Allium sylvestre campestre purpurascens* C.B.P. 74 b. *Porrum capite bulbifero, staminibus alterne trifidis* Hall. Enum. 295. *Allium vineale* L. Sp. 299.—Bonnier, Fl. Compl. x, t. 583, fig. 2616 ; R. 94 ; Dr. 120.—F. 422 ; *Allium caninum* Trag. Stirp. 748 !

197 B. *Allium campestre*, 143 r., quoad ic. mediam tantum. *Allium ursinum* Annot. Diosc. 46 v. *Allium sylvestre latifolium* C.B.P. 74 a ; J. 21 ; S. 12. *Allium foliis radicalibus latissimis, petiolatis, floribus umbellatis* Hall. Enum. 297. \**Allium ursinum* L. Sp. 300.—Dietr. Fl. Boruss. iv, t. 225 ; R. 94 ; Dr. 120.—Br. 189 ; F. 424 ; *Allium sylvestre* Trag. Stirp. 748 !

197 C. *Allium campestre*, 143 r., quoad ic. rectam tantum. *Allium sylvestre bicorne flore obsoleto* C.B.P. 74 b ; C. 211 ; J. 21. *Allium oleraceum* L. Sp. 299.—Reichb. Ic. Fl. Germ. x, t. 487, fig. 1067 ; Bonnier, Fl. Compl. x, t. 585, fig. 2626 ; R. 94 ; Dr. 120.—F. 423 ; *Allium caninum alterum* Trag. Stirp. 748 !

198. *Mentha corymbifera minor*, 143 v., cum ic. *Ageratum foliis serratis* C.B.P. 221 a ; J. 78 ; S. 39. *Achillea Ageratum* L. Sp. 897.—Regnault, Bot. II, t. 158 ; Plenck, Ic. Pl. Med. VII, t. 632 ; Reichb. Ic. Fl. Germ. XVI, t. 1013, fig. I ; R. 281 ; Dr. 674.—*Eupatorium Mesuae* Trag. Stirp. 515 !

The figure from Tragus supplied by Gesner is undoubtedly *Achillea Ageratum*. The description of *Mentha corymbifera minor* given by Cordus also agrees, so far as it goes, with *A. Ageratum*, and was probably drawn up from cultivated material. Cordus stated that the plant grew in the mountains of Würzburg (Bavaria) and was also cultivated in gardens by some people for the sake of its pleasant smell. The Würzburg locality is puzzling, since there is no yellow-flowered Composite indigenous in Bavaria that agrees with the description.

199. *Sanguisorba maior*, 144 r., ic. 143 v. *Pimpinella Sanguisorba major* C.B.P. 160 a ; J. 50 ; S. 24. *Pimpinella tetrastemon, foliis oblonge cordatis, spica brevi* Hall. Enum. 469. *Sanguisorba officinalis* L. Sp. 116.—Plenck, Ic. Pl. Med. I, t. 63 ; Dietr. Fl. Boruss. IV, t. 274 ; P.C. 45 ; R. 964.—F. 449 ; Tr. 470 !

The specimen in C. Bauhin's herbarium has been identified as *Poterium Sanguisorba* L. (C. 307).

200. *Sanguisorba minor*, 144 r., sine ic. *Pimpinella Sanguisorba minor hirsuta* C.B.P. 160 b ; C. 307 ; S. 24. *Pimpinella polystemon pinnis ovatis, serratis, spica brevi* Hall. Enum. 470. *Poterium Sanguisorba* L. Sp. 994.—Plenck, Ic. Pl. Med. VII, t. 668 ; Dietr. Fl. Boruss. XII, t. 812 ; L.P. 111 ; R. 965 ; Dr. 280.—F. 450.

201. *Daucus tenuifolius*, 144 r., sine ic. *Daucus tenuifolius* Cordi J. Bauh. Hist. III, pars 2, 58 b (1651). *Seseli annuum* L. Sp. 260.

Identified by Dierbach (Beitr. Deutschl. Fl. I, 120 : 1825) as *Seseli annuum* L., which is said to have the root blackish or brownish outside (Jacq. Fl. Austr. I, 34, t. 55 ; Dietr. Fl. Boruss. X, t. 709), whereas that of *Daucus tenuifolius* was described as yellowish ('sufflava') outside. In Zenker, Fl. Thüringen, II, t. 221, however, the root, though described as blackish outside, is figured as pale buff. According to August Schulz (Mitt. Thüring. Bot. Ver. N.F. XXXII, 60 : 1916) *Seseli annuum* does not now occur between Hildesheim and Hanover, whence Cordus recorded *Daucus tenuifolius*. It occurs, however, at Gosslar, about 25 miles south-east of Hildesheim (Hegi, Ill. Fl. V, pars 2, 1241).

202. *Allium sativum multifidum*, 144 r., excl. ic. 144 v. *Allium* Annot. Diosc. 46 v. *Allium sativum* C.B.P. 73 a ; J. 21 ; S. 12. *Allium sativum* L. Sp. 296 ;

G. Don in Mem. Wern. Soc. vi, 4 (1832).—Plenck, Ic. Pl. Med. iii, t. 254 ; Hayne, Arzn. Gewächse, vi, t. 6 ; B.T. 280 ; P.C. 113 ; L.P. 32 ; R. 92 ; H. 64.—Br. 245 ; F. 421.

The two figures on p. 144 v., taken from Tragus, Hist. 745, cannot be named with certainty.

\*203. *Allium sativum amphicarpon*, 144 v., sine ic. *Allium sativum alterum* : sive *Allioprassum caulis summo circumvoluto* C.B.P. 73 b ; J. 21. *Allii genus*, *Ophioscorodon dictum quibusdam* J. Bauh. Hist. ii, 559 a. *Allium Scorodoprassum* L. Sp. 297, var.  $\beta$ . *Allium sativum* Trev. Allii Species, 5 (1822), var.  $\beta$ . *Allium Ophioscorodon* G. Don in Mem. Wern. Soc. vi, 5 (1832). *Allium sativum* var. *Ophioscorodon* (G. Don) Döll, Rheinische Fl. 197 (1843) ; Alef. Landwirthsch. Fl. 297 ; Fischer-Benzon, Altdeutsche Gartenfl. 142 ; Becker, Handb. Gemüsebau, 1005.—R. 92.

The varietal name *Allium sativum* var. *Ophioscorodon* has priority over the name *A. sativum* var. *subrotundum* Gren. et Godr. (1855-56), adopted by Regel, Alliorum Monogr. 44.

\*204. *Allium simplex, individuumque*, 144 v., sine ic. *Allium sativum radice simplici* C.B.P. 74 a. *Allium controversum* Schrad. sec. G. Don in Mem. Wern. Soc. vi, 5 (1832). *Allium sativum* var. *controversum* Becker, Handb. Gemüsebau, 1006, non Regel.—Reichb. Ic. Fl. Germ. x, t. 488, fig. 1070.

According to Regel, Alliorum Monogr. 44 (Act. Hort. Petrop. iii, pars 2 : 1875), the specimens of *Allium controversum* Schrad. (Willd. Enum. 358 : 1809) in Schrader's herbarium have compound bulbs, not simple ones as described by the authors cited above. Regel (loc. cit.) distinguished *A. sativum* var. *controversum* (Schrad.) Regel principally by the purplish flowers, and assigned to *A. sativum* var. *subrotundum* Gren. et Godr. the figure named *A. controversum* in Reichb. Ic. Fl. Germ. x, t. 488, fig. 1070. The cultivated races of *Allium sativum* evidently require re-investigation.

205. *Lycotconum sativum tricarpon*, 145 r., cum ic. *Aconitum Stoerkianum* Reichb. ; Reichb. Uebers. Acon. 49 (1819) ; Ill. Spec. Acon. t. 18 ; Hegi, Ill. Fl. iii, 506 ; R. 615.—Tr. 248 !

An old garden plant, now regarded as a hybrid between *A. Napellus* L. and *A. variegatum* L.

206. *Lycotconum sativum pentacarpon*, 145 r., sine ic. *Aconitum pyramidale* Mill. sec. Reichb. Uebers. Acon. 48 (1819) ; Reichb. Ill. Spec. Acon. t. 15 ; Ic. Fl. Germ. iv, t. 89, fig. 4697. *Aconitum Napellus* subsp. *pyramidale* (Mill.) Gayer in Hegi, Ill. Fl. iii, 500 ; R. 616 ; H. 1 (*A. Napellus*).

207. *Absynthium*, 145 r., ic. 145 v. ; Annot. Diosc. 51 v. *Absinthium Ponticum seu Romanum officinarum, seu Dioscoridis* C.B.P. 138 a ; C. 302 ; J. 40 ; S. 20. *Artemisia foliis incanis, pinnatis, pinnis bilobis latioribus, floribus ex alis pendulis, in spicis heteromallis* Hall. Enum. 696. *Artemisia*

*Absinthium* L. Sp. 848.—Hayne, Arzn. Gewächse, II, t. 11 ; Dietr. Fl. Boruss. IX, t. 633 ; B.T. 156 ; P.C. 308 ; L.P. 31, 127 ; R. 284 ; H. 1, 258.—Br. 193 ; F. 1 ; Tr. 335 !

\*208. *Absynthium dulce*, 145 v., sine ic.—*Absinthium insipidum* Gesn. Hort. Germ. 244 r. *Absinthium insipidum*, *absinthio vulgari simile* C.B.P. 139 a. *Artemisia Absinthium* L., var. *insipida* Bess. ex DC. in DC. Prodr. VI, 125 (1837) ; Alef. Landwirthsch. Fl. 175 (1866).

The name *absinthium dulce* appears to have been used in the thirteenth and fifteenth centuries for the Dill plant, *Anethum graveolens* L. (Tschirch, Handb. Pharmakogn. I, 641, sub *anethum* ; Hermann Fischer, Mittelalt. Pflanzenk. 259, sub *Anethum graveolens*), which is an annual or a biennial. *Absynthium dulce* V. Cord., on the other hand, is described as having a perennial root, the taste of *Artemisia* (*Artemisia vulgaris*), and the form of *Absynthium* (*Artemisia Absinthium*).

209. *Artemisia maior*, 145 v., ic. 146 r. *Artemisia* Annot. Diosc. 58 r. *Artemisia vulgaris maior* C.B.P. 137 a ; J. 40 ; S. 20. *Artemisia foliis planis semipinnatis, pinnis rariter dentatis, floribus erectis, dense spicatis* Hall. Enum. 696. *Artemisia vulgaris* L. Sp. 848.—Hayne, Arzn. Gewächse, II, t. 12 ; Dietr. Fl. Boruss. IX, t. 634 ; P.C. 192 ; L.P. 177 ; R. 286.—Br. 139 ; F. 24 ; Tr. 344 !

210. *Satureia sive Thymbra sativa*, 145 v., ic. 146 r. ; Annot. Diosc. 53 r. *Satureia hortensis sive Cunila sativa, Plinii* C.B.P. 218 a ; J. 77 ; S. 38. *Satureja hortensis* L. Sp. 568.—Hayne, Arzn. Gewächse, VI, t. 9 ; P.C. 250 ; L.P. 34, 152 ; R. 410.—F. 172 ; Tr. 45 !

211. *Thymbra, quae sylvestris satureia est*, 146 r., sine ic. *Thymbra sylvestris* Annot. Diosc. 53 r. *Satureja Thymbra* L. Sp. 567.—Sibth. Fl. Graec. VI, t. 541 ; Reichb. Ic. Fl. Germ. XVIII, t. 1270, I ; R. 411 ; Dr. 580.—*Epygradium* Alb. Magn. I, 138 ? *Thymbra* Cordus, Dispens. 8 (1546).

Identified in C.B.P. 218 a as *Satureia montana* (*Satureja montana*), Winter Savory, which is used as a flavouring in cooking. The description—"sativae satureiae in cunctis similis existit, durioribus tamen et magis hirtis foliis constat"—and the statement that the plant was brought from Crete and neighbouring regions point rather to *S. Thymbra*.

212 A. *Stachys*, 146 r., excl. ic. 146 v. *Marrubium peregrinum* L. Sp. 582 (*M. creticum* Mill.) ; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. xxx. 65 (1913), et op. cit. xxxiii, 63 (1916) ; Hegi, Ill. Fl. v, pars 4, 2398.—Jacq. Fl. Austr. II, t. 160 ; Reichb. Pl. Crit. III, t. 288.—R. 420.

*Stachys* Annot. Diosc. 58 r. appears to be *Stachys germanica* L.—vide seq.

212 B. *Stachys*, 146 v., quoad ic. tantum. *Stachys major Germanica* C.B.P. 236 a ; C. 469 ; J. 84 ; S. 42. *Stachys foliis tomentosis albis, verticillis densissimis, ad basin exsectis, longe decrescentibus* Hall. Enum. 643. *Stachys germanica* L. Sp. 581.—Jacq. Fl. Austr. IV, t. 319 ; Dietr. Fl. Boruss. V, t. 344 ; Reichb. Ic. Fl. Germ. XVIII, t. 1210, I, II ; R. 419 ; Dr. 575.—F. 437 ; Tr. 9 !

213. *Scolymus*, 146 v., cum ic. ; Annot. Diosc. 51 r. *Scolymus Dioscoridis* Clus. Rar. Pl. Hist. v, p. cliii (1601). *Cinara hortensis aculeata* C.B.P. 383 a ; J. 140 ; S. 70. *Cynara Scolymus* L. Sp. 827, var.  $\beta$ . *Cynara Scolymus* var. *aculeatus* Alef. Landwirthsch. Fl. 178 ; R. 301 ; H. 8.—F. 451 ; Tr. 866 !

214. *Hipposelinum*, 147 r., cum ic. ; *Olusatrum* Annot. Diosc. 55 v. *Hipposelinum Theophrasti vel Smyrniium Dioscoridis* C.B.P. 154 a ; J. 47 ; S. 23. *Smyrniium Olusatrum* L. Sp. 262.—Plenck, Ic. Pl. Med. III, t. 220 ; Reichb. Ic. Fl. Germ. XXI, t. 2035 ; R. 557 ; Dr. 487.—F. 186.

\*215. *Brassica agrestis*, 147 r., sine ic. *Brassica campestris perfoliata flore albo* C.B.P. 112 a ; C. 215. *Eruca foliis ovatis integerrimis amplexicaulibus* Hall. Hist. I, 199. *Brassica orientalis* L. Sp. 666. *B. perfoliata* Lam. *Conringia orientalis* (L.) Dumort. ; Hegi, Ill. Fl. IV, pars 1, 440 ; O. E. Schulz in Engl. Pflanzenr. IV, 105 (Cruciferae-Brassicaceae), pars 2, 86.—Jacq. Fl. Austr. III, t. 282 ; Reichb. Ic. Fl. Germ. II, t. 61, fig. 4382 ; R. 642 ; Dr. 260.

216. *Ocimum Nabathaeum*, 147 r., sine ic. *Ocimum Nabathi* Annot. Diosc. 46 r. *Ocimum vulgatius* C.B.P. 226 a. *Ocimum Basilicum* L. Sp. 597, var. *vulgare* Alef. Landwirthsch. Fl. 114, forma.—P.C. 22 ; L.P. 168 ; R. 394 ; Dr. 586.—F. 310.

217. *Ocimum caryophyllatum*, 147 v., cum ic. ; Annot. Diosc. 46 r. *Ocimum minimum* C.B.P. 226 b. *Ocimum minimum* L. Sp. 597. *Ocimum Basilicum* L. var. *minimum* (L.) Alef. Landwirthsch. Fl. 114.—Schkuhr, Bot. Handb. ed. 2, t. 166 ; R. 395 ; Dr. 587.—F. 309 ; Tr. 30 !

218. *Drosera seu Drosion, sive Psiadeion, quam vulgo Alchimillam vocant* 147 v., cum ic. *Alchimilla vulgaris* C.B.P. 319 a ; C. 732 ; S. 59. *Alchimilla folio integro stellato polygonio* Hall. Enum. 184. *Alchemilla vulgaris* L. Sp. 123.—Plenck, Ic. Pl. Med. I, t. 69 ; Dietr. Fl. Boruss. VII, t. 489 ; P.C. 158 ; L.P. 98 ; R. 963.—Br. 116 ; F. 348 ; Tr. 512 !

219. *Samsuchus quae Latinis Maiorana vocatur*, 148 r., cum ic. *Sampsuchum* Annot. Diosc. 53 r. *Majorana vulgaris* C.B.P. 224 b ; J. 79 ; S. 39. *Origanum Majorana* L. Sp. 590.—Hayne, Arzn. Gewächse, VIII, t. 9 ; P.C. 181 ; L.P. 145 ; R. 409 ; H. 108, 128.—F. 379 ; Tr. 33 !

220. *Rosmarinus sylvestris seu maior*, 148 r., sine ic. *Rosmarinus spontaneus latiore folio* C.B.P. 217 b ; J. 77. *Rosmarinus officinalis* L. Sp. 23 (var.  $\alpha$ ).—Hayne, Arzn. Gewächse, VII, t. 25 ; B.T. 207 ; L.P. 146 ; R. 406 ; H. 166.—Br. 122 ; F. 271.

The use of the term "virgae" to designate the branches suggests that *Rosmarinus sylvestris seu maior* was *R. officinalis* var. *rigidus* Cariot et St. Lag. (*R. rigidus* Jord. et Fourr. ; Ic. Fl. Eur. I, t. 101) rather than var. *latifolius* (Mill.) Bég. (*R. flexuosus* Jord. et Fourr. ; Ic. Fl. Eur. I, t. 102). The figure in Fuchs, however, seems to represent the latter (see no. 221 B).

221 A. *Rosmarinus minor seu tenuifolius*, 148 v., excl. ic. *Libanotis coronaria* Annot. Diosc. 56 v. *Rosmarinus hortensis angustiore folio* C.B.P. 217 a ; J. 77. *Rosmarinus officinalis* L. Sp. 23, var.  $\beta$ . *Rosmarinus officinalis* L. var. *angustifolius* Guss. Suppl. Fl. Sic. Prodr. fasc. 1, 4 (1832).—Jord. et Fourr. Ic. Fl. Eur. I, t. 103.

Described by Cordus as smaller in all its parts than *Rosmarinus sylvestris seu maior* and possessing a sweeter scent ; the epithet *tenuifolius* indicates that the leaves were also narrower. These points agree, as far as they go, with Gussone's description of his var. *angustifolius* : " Frutex in Lampedusa humillimus, sed ejus folia fragrantissima, vix  $\frac{1}{2}$  lin. lata, supra aliquanto pubescentia, subtus vix tomentosa."

221 B. *Rosmarinus minor*, 148 r., quoad ic. tantum. *Rosmarinus officinalis* L. Sp. 23.—F. 271 ; Tr. 55 !

The figure taken from Tragus, and originally adapted from the one in Fuchs, Hist. 478, apparently represents *R. officinalis* var. *latifolius* (Mill.) Bég. (*R. flexuosus* Jord. et Fourr. ; Ic. Fl. Eur. I, t. 102).

222. *Pityospermon*, 148 v., sine ic. *Odorata* Riv. Pentapet. 18, t. 57. *Scandix Odorata* L. Sp. 256. *Myrrhis Odorata* (L.) Scop.—Jacq. Fl. Austr. v, 41, App. t. 37 ; Lindm. Bilder Nordens Fl. t. 265 ; P.C. 69 ; R. 555 ; Dr. 486.

Referred by Dierbach (Beitr. Deutschl. Fl. I, 127 : 1825) to *Chaerophyllum hirsutum* L.

223. *Malva sylvestris supina*, 148 v., ic. 149 r. *Malva sylvestris folio rotundo* C.B.P. 314 a ; C. 731 ; S. 58. *Malva caule repente, foliis caudato orbicularibus obsolete quinquelobis* Hall. Enum. 363. *Malva rotundifolia* L. Sp. 688.—Dietr. Fl. Boruss. III, t. 190 ; R. 706 ; Dr. 421.—Br. 131 ; F. 289 ; Tr. 369 !

224. *Olsenichium*, 149 r., sine ic. *Olsenichium* Th. 80 ; Sch. 58. *Apium sylvestre lacteo succo turgens* C.B.P. 153 b ; C. 306. *Selinum sylvestre* L. Sp. 244. *Selinum palustre* L. Sp. 244. *Peucedanum palustre* (L.) Moench.—Svensk Bot. VI, t. 380 ; Reichb. Ic. Fl. Germ. XXI, t. 1966 ; R. 546 ; Dr. 499 ; Pritzel u. Jessen, Deutsch. Volksnamen, 270.—*Apium sylvestre* Dod. Cruydeb. 650 (1554).

This species is figured by Gesner on p. 133 r., ic. sinistra—vide no. 164 B.

225. *Santonium maius*, 149 r., sine ic. *Abrotonum femina vulgatus* Clus. Hist. I, 341 (1601). *Santolina Chamaecyparissus* L. Sp. 842, forma.—Hayne, Arnz. Gewächse, VI, t. 19 ; P.C. 161 ; L.P. 30 ; R. 281 ; Dr. 673.—F. 499.

The description given by Cordus seems to agree, as far as it goes, with that of *Abrotonum femina vulgatus* Clus., which Willdenow (Sp. Pl. III, 1798) refers to *Santolina squarrosa* Willd. (*S. Chamaecyparissus* var. *squarrosa* DC.).

226 A. *Santonicum minus*, 149 v., excl. ic. *Cupressus herba quam Graeci Chamaecyparissum nominant* Annot. Diosc. 51 v., cap. 26. *Santolina Chamaecyparissus* L. Sp. 842, forma.

Distinguished from *Santonicum maius* by its smaller stems and leaves, and milder taste and smell.

226 B. *Santonicum minus*, 149 v., quoad ic. tantum. *Santolina Chamaecyparissus* L.

The figure added by Gesner from Tragus, Hist. 77, is adapted from the one in Fuchs, Hist. 874, which cannot be referred to any particular variety.

227 A. *Hyacinthus sylvestris*, 149 v., ic. dextra. *Hyacinthus quem Medici intelligunt* Annot. Diosc. 66 r. *Hyacinthus comosus major purpureus* C.B.P. 42 a ; C. 209 ; J. 17 ; S. 10. *Hyacinthus comosus* L. Sp. 318. *Muscari comosum* (L.) Mill.—Dietr. Fl. Boruss. I, t. 42 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl., ed. 5, III, t. 273 ; R. 90 ; Dr. 124.—F. 475 ; *Hyacinthus maior* Tr. 772 !

The description of the leaves as nearly  $\frac{1}{2}$  in. broad, and of the peduncle as marked with red spots, as well as the mention of a dense terminal crown (*coma*) of flowers with paler and more scattered ones beneath, suggest *Muscari comosum*. Cordus may have included also *Muscari tenuiflorum* Tausch ; Hegi, Ill. Fl. II, 259—vide Aug. Schultz in Mitt. Thüring. Bot. Ver. N.F. XXXIII, 50 (1916).

227 B. *Hyacinthus sylvestris*, 149 v., quoad ic. sinistram tantum. *Hyacinthus minor et Hyacinthus minor candidus* Sylv. 221 v. *Hyacinthus botryoides* L. Sp. 318, et ed. 2, 455. *Muscari botryoides* (L.) Mill.—Bonnier, Fl. Compl. x, t. 589, fig. 2646 b ; R. 90 ; Dr. 124.—F. 476 ; *Hyacinthus vernus exiguus* Tr. 772 !

The figure in Tragus is adapted from the one in Fuchs, Hist. 836.

228. *Limnopleuce*, 150 r., sine ic. *Equisetum palustre brevioribus foliis polyspermon* C.B.P. 15 b. *Limnopleuce* Hall. Enum. 197 ; Enum. Pl. Gott. 38. *Hippuris vulgaris* L. Sp. 4.—Dietr. Fl. Boruss. v, t. 304 ; Zenker, Fl. Thüring. v, t. 581 ; R. 909 ; Dr. 483.

229. *Phyllitis lacustris*, 150 r., sine ic. *Potamogeton ιεροφύλλου* Th. 86 ; Sch. 25. *Potamogeton, Salicis folio* C.B.P. 193 a ; C. 312 ; J. 65 ; S. 31. *Polygonum amphibium* L. Sp. 361.—Dietr. Fl. Boruss. IV, t. 283 ; Hegi, Ill. Fl. III, t. 93, fig. 3 ; R. 220 ; Dr. 193.

\*230. *Testiculus bifolius*, 150 r., sine ic. *Orchis alba bifolia minor calcare oblongo* C.B.P. 83 a. *Orchis radicibus conicis, labello lingulato, simplicissimo* Hall. Enum. 266, partim. *Orchis bifolia* L. Sp. 939, partim. *Platanthera chlorantha* (Custer) Reichb.—see the remarks under no. 153 A (*Platanthera bifolia*).

231. *Palma montana*, 150 v., sine ic. *Gymnadenia conopsea* (L.) R. Br.—Nelson, Orch. Deutschl. t. 14, fig. 44.—F. 406.—vide nos. 153 B, 159 B.

Compared with the preceding, from which it is stated to differ by the terete stem and more numerous, smaller, purple flowers.

232. *Liliago*, 150 v. *Phalangium* Gesn., ic., 150 v. *Liliago Cordi*, species minor Th. 69, 70; Sch. 21. *Anthericum ramosum* L. Sp. 310.—Dietr. Fl. Boruss. 1, t. 54; Hegi, Ill. Fl. II, t. 59, fig. 1; Bonnier, Fl. Compl. x, t. 591, fig. 2652; R. 95; Dr. 116.

The description of the flowers as borne at the top of the stem and on the lateral branches indicates *Anthericum ramosum*: "in summo caule et adnatis flores producit." The term *adnatum* was used in the sixteenth century to denote a lateral branch (vide Kew Bull. 1936, 153). *Liliago* Cord. was cited erroneously under *Phalangium parvo flore non ramosum* C.B.P. 29 a, and *Phalangium radicebus teretibus, caule spicato, nudo, foliis gramineis, petiolis florum non ramosis* Hall. Enum. 292, which are synonyms of *Anthericum Liliago* L. (C. 208).

\*233. *Damasonium tenuifolium*, 151 r., sine ic. *Helleborine longifolia*, floribus magnis paucis albisque Hall. Enum. 275. *Epipactis caule pauciflora, lineis in obtuso labello obviis*, var.  $\beta$  *foliis ensiformibus* Hall. Hist. II, 155. *Alisma Kentmanni foliis angustioribus* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. II, 11 (1770). *Serapias Xiphophyllum* L. f. Suppl. 404 (1781). *Serapias ensifolia* Murr. Syst. ed. 14, 815 (1784). *Epipactis ensifolia* Sw. in K. Svensk Vetensk. Acad. Nya Handl. XXI, 232 (1800). *Cephalanthera ensifolia* (Murr.) L. C. Rich. *Cephalanthera Xiphophyllum* (L. f.) Reichb. Ic. Fl. Germ. XIII, & XIV, 135, t. 470 (1851).—Dietr. Fl. Boruss. 1, t. 19; Hegi, Ill. Fl. II, 381, fig. 444; Nelson, Orch. Deutschl. t. 20, fig. 60; Dr. 151.

\*234. *Damasonium calliphyllon*, 151 r. *Alisma quorundam* Gesn., ic. 150 v. *Helleborine flore albo, vel Damasonium montanum latifolium* C.B.P. 187 a; J. 62. *Helleborine latifolia, floribus magnis, paucis albisque* Hall. Enum. 276. *Epipactis caule pauciflora, lineis in obtuso labello levibus*, var.  $\alpha$  *latifolia, foliis ovato-lanceolatis* Hall. Hist. II, 155, t. 41. *Alisma Kentmanni foliis latioribus* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. II, 11, t. 17, no. 59 (1770). *Serapias grandiflora* L. Syst. ed. 12, II, 594 (1767), partim. *Serapias Damasonium* Mill. (1768). *Serapias latifolia* Mill. (1768). *Serapias lancifolia* Murr. Syst. ed. 14, 815 (1784). *Epipactis pallens* Sw. (1805); Willd. Sp. IV, 85 (1805). *Cephalanthera pallens* (Willd.) L. C. Rich. (1818). *Cephalanthera grandiflora* (L.) S. F. Gray (1821). *Cephalanthera latifolia* (Mill.) Janchen (1907).—Dietr. Fl. Boruss. 1, t. 18; Hegi, Ill. Fl. II, 381, fig. 443; Nelson, Orch. Deutschl. t. 19, fig. 58.

Schmidel referred *Alisma quorundam* Gesn. to *Alismatis species quae Helleborastrum album vocari potest* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. II, t. 19, no. 61 (1770), which is *Epipactis latifolia* (L.) All.

235. *Anemone tenuifolia*, 151 r., cum ic. *Adonis sylvestris flore phoeniceo ejusque foliis longioribus* C.B.P. 178 a; J. 58. *Adonis annua, octopetalos* var.



*humilior, flore miniato* Hall. Enum. 320. *Adonis radice annua, flore octopetalo* var.  $\beta$  *flore cinnabarino, humilior, et flore minori* Hall. Hist. 66. *Adonis annua* var.  $\alpha$  *phoenicea* L. Sp. 547. *Adonis aestivalis* L. Sp. ed. 2, 771 (1762).—Dietr. Fl. Boruss. xi, t. 777; Reichb. Ic. Fl. Germ. iv, t. 24, fig. 4619; Hegi, Ill. Fl. III, t. 121, fig. 4; R. 606; Dr. 229.—Tr. 128!

The figure in Tragus, Hist. 128, has two of the three flowers drawn with four broad petals in order to agree with the statement in the text: "Ea sub initia Iunii mensis, flosculos quatuor foliolis distinctis, minii colore tinctos, aliquando candidos, per omnia Argemonem minutam, exprimentes, gerit." ("Gewint im Anfang des Brochmonats schoene kleyne mengefarte rotte Roesslin mit vier bletlin an yeder bluomen aller ding sind dise Roesslin den kleynen Klapper Roesslin gleich"—Bock, New Kreütter Buoch, 1, fol. xxxi. v., no. 7: 1539). Tragus evidently had the forma *oligopetala* Reichb., Ic. Fl. Germ. iv, t. 24, fig. 4619.

\*236. *Anemone tenuifolia altera*, 151 r., sine ic. *Adonis aestivalis* L. var. *citrina* (Hoffm. 1800).—Reichb. Ic. Fl. Germ. III, t. 24, fig. 4619.

\*237 A. *Coralloides*, 151 v., excl. ic. *Coralloides Cordi* Th. 35; Sch. 14. *Dentaria heptaphyllos baccifera* C.B.P. 322 b; J. 119; S. 59. *Dentaria foliis inferioribus pinnatis supernis simplicibus* Hall. Enum. 557. *Dentaria seu Coralloides Cordi* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. 1, 3, 40, t. 2, fig. 3 (1759). *Dentaria bulbifera* L. Sp. 653.—Zenker, Fl. Thüringen, VI, t. 705; Bonnier, Fl. Compl. t. 44, fig. 206; R. 632; Dr. 258.

\*237 B. *Coralloides*, 151 v., quoad ic. tantum. *Coralloides triphyllus, cognata Saxifragae montanae* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. 1, 4, 40, t. 2, fig. 4. *Dentaria enneaphyllos* L. Sp. 653; Aug. Schultz in Mitt. Thüring. Bot. Ver. N.F. XXXIII, 55 (1916).—Jacq. Fl. Austr. iv, t. 316; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xiv, t. 1371; R. 632; Dr. 258.

238. *Coralloidis alia species*, 151 v., ic. tantum. *Dentaria heptaphyllos baccifera* C.B.P. 322 b. *Dentaria foliis inferioribus pinnatis supernis simplicibus*, var.  $\beta$ , Hall. Enum. 557. *Dentaria seu Coralloides Cordi* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. 1, 3, 40, t. 2, fig. 3 (1759). *Dentaria bulbifera* L. Sp. 653.—vide No. 237 A.

Apparently a bad figure of the upper part of the stem of *Dentaria bulbifera* L. shown as directly attached to the rhizome. See the figures cited under no. 237 A.

239. *Aconitum seu Pardalianches monococcon*, 151 v., ic. 152 r. *Aconitum Pardalianches* Annot. Diosc. 67 v. *Herba Paris* Thal. Sylv. Hercyn. 57 (1588). *Solanum quadrifolium bacciferum* C.B.P. 167 a; C. 308; J. 54; S. 26. *Paris foliis quaternis* Hall. Enum. 412. *Paris quadrifolia* L. Sp. 367.—Hayne, Arzn. Gewächse, III, t. 7; Dietr. Fl. Boruss. I, t. 39; R. 99; Dr. 127.—F. 47; Tr. 308!

240. *Dracunculus primus sive polyphyllus* . . . *Luph crispum*, 152 r., cum ic. *Dracunculus maior sive Luph crispum* Annot. Diosc. 48 r. *Dracunculus polyphyllus* C.B.P. 195 a ; C. 459 ; J. 66 ; S. 32. *Arum Dracunculus* L. Sp. 964. *Dracunculus vulgaris* Schott.—Sibth. et Sm. Fl. Graec. x, t. 946 ; Schott, Aroid. tt. 23, 24.—Br. 16 ; F. 133 ; Tr. 777 !

241. *Dracunculus alter seu henicophyllos*, 152 v., sine ic. *Dracunculus minor sive Luph planum* Annot. Diosc. 48 r. *Arum venis albis* C.B.P. 195 a ; C. 459 ; J. 66. *Arum italicum* Mill. Gard. Dict. ed. 8 (1768), no. 2 ; Willd. Sp. Pl. iv, 484.—Bot. Mag. t. 2432 ; Reichb. Ic. Fl. Germ. vii, t. 11.

242. *Dracunculus maior*, 152 v., ic. tantum.—Figure copied from that of *Dracunculus maior* Matth. Comm. 288 (1554). Not identified, possibly fictitious.

243. *Hepatica alba*, 153 r., ic. 152 v. *Gramen Parnassi albo simplici flore* C.B.P. 309 a ; C. 731 ; J. 115 ; S. 57. *Parnassia* Hall. Enum. 316. *Hepatica alba* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. I, 9, t. 4, n. 11 (1759). *Parnassia palustris* L. Sp. 273.—Hayne, Arzn. Gewächse, II, t. 42 ; Dietr. Fl. Boruss. II, t. 143 ; R. 657 ; Dr. 268.

244. *Verbascum leptophyllum*, 153 r., cum ic. *Blattaria lutea folio longo laciniato* C.B.P. 240 b ; C. 469 ; J. 86 ; S. 43. *Verbascum foliis glabris, serrato dentatis, radicalibus sinuatis* Hall. Enum. 511. *Verbascum Blattaria* L. Sp. 178.—Zenker, Fl. Thüringen, XII, t. 1417 ; Reichb. Ic. Fl. Germ. xx, t. 1653 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xvii, t. 1623 ; Hegi, III. Fl. vi, pars 1, 9, fig. 1.—R. 470 ; Dr. 602.—F. 102 ; Tr. 925 !

245. *Mentha corymbifera maior*, 153 r. *Mentha corymbifera*, ic. 153 v. *Mentha hortensis corymbifera* C.B.P. 226 b ; C. 466 ; J. 80 ; S. 40. *Tanacetum Balsamita* L. Sp. 845.—Hayne, Arzn. Gewächse, II, t. 5 ; Hegi, III. Fl. vi, pars 2, 599, fig. 314 ; L.P. 175 ; R. 289 ; Dr. 677.—Tr. 163 !

246. *Lingula vulneraria*, 153 v., cum ic. *Ophioglossum vulgatum* C.B.P. 354 a ; J. 132 ; S. 67. *Ophioglossum* Hall. Enum. 131. *Ophioglossum vulgatum* L. Sp. 1062.—Hayne, Arzn. Gewächse, vi, t. 48 ; P.C. 3 ; R. 49 ; Dr. 60.—F. 328 ; Tr. 323 !

247 A. *Psyllium*, 154 r., excl. ic. *Psyllium, sive Pulicaris* Annot. Diosc. 67 r. *Psyllium majus erectum* C.B.P. 191 b ; C. 312 ; J. 64. *Plantago caule ramoso, erecto* Hall. Enum. 470. *Plantago indica* L. Syst. ed. 10, 896 (1759).—*Plantago arenaria* Waldst. et Kit. Pl. Rar. Hung. I, 51, t. 51.—Hayne, Arzn. Gewächse, v, t. 16 ; L.P. 16 ; R. 251, 1114 ; Dr. 618.—F. 506 ; Tr. 167.

*Psyllium* Fuchs, Hist. 888, previously referred (F. 506) to *Plantago Psyllium* L., is now identified as *Plantago indica* on account of the entire leaves and oblong-ovoid spikes with conspicuous recurved basal bracts.

247 B. *Psyllium*, 154 r., quoad ic. tantum. *Conyza major flore globoso* C.B.P. 266 a; C. 723; J. 97; S. 48. *Inula Pulicaria* L. Sp. 882; Willd. Sp. Pl. III, 2093. *Pulicaria vulgaris* Gaertn.—Dietr. Fl. Boruss. VIII, t. 562; Hegi, Ill. Fl. VI, pars 1, 488, fig. 246; R. 270; Dr. 667.—Tr. 166!—vide no. 271 B.

248. *Tanacetum*, 154 r., ic. 154 v. *Tanacetum vulgare luteum* C.B.P. 132 a; C. 301; J. 38; S. 19. *Tanacetum foliis pinnatis, pinnis semipinnatis, floribus umbellatis* Hall. Enum. 694. *Tanacetum vulgare* L. Sp. 844.—Plenck, Ic. Pl. Med. VII, t. 611; Hayne, Arzn. Gewächse, II, t. 6; P.C. 279; L.P. 29; R. 288; Dr. 676; H. 207.—Br. 87; F. 26; Tr. 158!

249. *Daucus Selinoides*, 155 r., ic. 154 v. *Pimpinella vulgaris seu minor* Th. 8, in obs.; *P. nostras communis minor* Th. 87; Sch. 26. *Pimpinella saxifraga minor* C.B.P. 160 a; C. 307; J. 50; S. 24. *Daucus Selinoides Cordi* J. Bauh. Hist. III, pars 2, 59 a. *Tragoselinum pinnis subrotundis, circumserratis* Hall. Enum. 429. *Pimpinella saxifraga* L. Sp. 263.—Hayne, Arzn. Gewächse, VII, t. 20; Nees, Pl. Med. t. 273; Dietr. Fl. Boruss. X, t. 704; P.C. 45; R. 532; Dr. 489.—Br. 144; Tr. 466!—vide nos. 251, 252.

Referred by Dierbach (Beitr. Deutschl. Fl. I, 124; 1825) to *P. saxifraga* var. *dissecta* (Retz.) Spreng. *Daucus* Annot. Diosc. 56 r. included species of *Pimpinella*, and apparently *Tordylium maximum* L. (no. 269), in addition to *Pastinaca gallica* Plin., the cultivated Parsnip (*Pastinaca sativa* L.). *Pastinaca erratica* Annot. Diosc. 54 r. was the wild Carrot (*Daucus Carota* L.).

\*250. *Daucus Cyanopus*, 155 r., sine ic. *Pimpinella saxifraga major altera* C.B.P. 159 b. *Daucus Cyanopus Cordi* J. Bauh. Hist. III, pars 2, 59. *Saxifraga hircina minor foliis Sanguisorbae* J. Bauh. loc. cit. 111 b. *Tragoselinum maius caeruleum* Walther, Design. Pl. Hort. 111. *Tragoselinum pinnis semilobatis circumserratis* Hall. Enum. 429, subsp. II, var.  $\beta$ . *Pimpinella nigra* Mill. Gard. Dict. ed. 8, no. 4 (1768); Willd. Fl. Berol. Prodr. 110 (1787); Roth, Tent. Fl. Germ. I, 129, et II, 342 (1788); Willd. Sp. Pl. I, 1471 (1798); Kostel. Med.-Pharm. Fl. IV, 1138 (1835).—*Pimpinella saxifraga* var. *nigra* (Mill.) Spreng. Sp. Umbellif. 116 (1818). *P. saxifraga* subsp. *nigra* Gaud. Fl. Helvet. II, 440 (1828); Hegi, Ill. Fl. V, pars 2, 1206.—Dietr. Fl. Boruss. X, t. 705; Zenker, Fl. Thüringen, XII, t. 1437.

Referred by Dierbach (loc. cit.) to *P. saxifraga* L. var. *nigra* (Mill.) Spreng.

251. *Daucus coriophyllus*, 155 r., sine ic. *Daucus coriophyllus Cordi* J. Bauh. Hist. III, pars 2, 59 a (1651). *Tragoselinum pinnis semilobatis, circumserratis* Hall. Enum. 429, subsp. II, var.  $\gamma$ . *Pimpinella saxifraga* L., forma.

Referred by Dierbach (loc. cit. 123) to *Pimpinella magna* L. var. *dissecta* Spreng., but that has hollow strongly-furrowed stems, whereas Cordus described those of his *Daucus coriophyllus* as solid and finely striate.

252. *Daucus conioophyllus*, 155 r., sine ic. *Daucus conioophyllos foliis Cicutae*, Gordi J. Bauh. Hist. III, pars 2, 59 b. *Pimpinella saxifraga* L., forma.

Referred by Dierbach (loc. cit. 127) to *Anthriscus sylvestris* Hoffm.

\*253. *Polychrestum*, 155 v., sine ic. *Apium montanum folio ampliore* C.B.P. 153 b ; C. 306 ; J. 47 ; S. 23. *Selinum pinnis ad angulos obtusos pinnatis, pinnulis incis, non serratis* Hall. Enum. 444. *Athamanta Oreoselinum* L. Sp. 244. *Selinum Oreoselinum* (L.) Crantz. *Peucedanum Oreoselinum* (L.) Moench.—Jaq. Fl. Austr I, 43, t. 68 ; Nees, Pl. Med. t. 291 ; Hayne, Arzn. Gewächse, VII. t. 3 ; Pritzel u. Jessen, Deutsch. Volksnamen, 269 ; R. 545 ; Dr. 497.

254. *Hircibarba*, 155 v., ic. 156 r. ; Annot. Diosc. 46 r. *Tragopogon pratense luteum majus* C.B.P. 274 a ; C. 725 ; J. 102 ; S. 51. *Tragopogon foliis carinatis, amplexicaulibus, gramineis, flore luteo* Hall. Enum. 758. *Tragopogon pratensis* L. Sp. 789.—Dietr. Fl. Boruss. XII, t. 838 ; R. 307 ; Dr. 693.—F. 468 ; Tr. 280 !

255. *Portulaca agrestis sive sponte nascens*, 156 r., sine ic. *Portulaca sylvestris* Annot. Diosc. 44 v. *Portulaca angustifolia sive sylvestris* C.B.P. 288 a ; J. 108 ; S. 54. *Portulaca foliis cuneiformibus sessilibus* Hall. Enum. 392. *Portulaca oleracea* L. Sp. 445 (var.  $\alpha$ ). *Portulaca oleracea* L. var. *sylvestris* DC. in DC. Prodr. III, 353 ; Alef. Landwirthsch. Fl. 110.—Sibth. et Sm. Fl. Graec. v, t. 457 ; L.P. 34 ; R. 693 ; Dr. 205.—F. 62.

256. *Portulaca sativa*, 156 v., cum ic. *Portulaca* Annot. Diosc. 44 v. *Portulaca latifolia, seu sativa* C.B.P. 288 a ; J. 108 ; S. 54. *Portulaca oleracea* L. Sp. 445, var.  $\beta$ . *Portulaca oleracea* L. var. *sativa* DC. in DC. Prodr. III, 353 ; Alef. Landwirthsch. Fl. 111.—Regn. Bot. II, t. 1 ; Useful Plants of Japan, fig. 74.—F. 61 ; Tr. 382 !

\*257. *Garosmum, id est Vulvaria*, 156 v., sine ic. *Atriplex foetida* C.B.P. 119 b ; C. 216. *Chenopodium Vulvaria* L. Sp. 220.—Dietr. Fl. Boruss. XII. t. 847 ; Hegi, Ill. Fl. III, t. 95, fig. 3 ; R. 210 ; Dr. 194.

258. *Mentastrum*, 156 v., ic. 157 r. ; Annot. Diosc. 52 v. *Mentha sylvestris longiore folio* C.B.P. 227 b ; C. 466 ; J. 80 ; S. 40. *Mentha spicata* var.  $\beta$  *longifolia* L. Sp. 576. *Mentha sylvestris* L. Sp. ed. 2, 804.—Hayne, Arzn. Gewächse, XI, t. 34 ; Dietr. Fl. Boruss. v, t. 310 ; P.C. 137 ; R. 399 ; Dr. 584.—F. 166 ; Tr. 20 !

259. *Sonchus lenis aut laevis*, 157 r., sine ic. *Sonchus* Annot. Diosc. 45 r. *Sonchus laevis* Cordi Th. 107 ; Sch. 31. *Sonchus laevis laciniatus latifolius* C.B.P. 124 a ; J. 32 ; S. 16. *Sonchus foliis levibus et teneris, calycibus glabris* Hall. Enum. 753, var.  $\beta$ . *Sonchus oleraceus* var.  $\alpha$  *laevis* L. Sp. 794. *Sonchus oleraceus* L. em. Wallr. Sched. Crit. 431 (1822) ; Bischoff, Beitr. 217.—Syme, Engl. Bot. v, t. 810 ; Hayne, Arzn. Gewächse, I, t. 48 ; R. 309 ; Dr. 692.—F. 384.

260. *Sonchus asper maior*, 157 v., sine ic. *Sonchus asper non laciniatus* C.B.P. 123 a ; J. 32. *Sonchus asper* Hill.—vide seq.

261. *Sonchus asper minor*, 157 v., sine ic. *Sonchus asper laciniatus et non laciniatus* C.B.P. 124 a ; C. 297 ; J. 32. *Sonchus foliis rigidiusculis serratis*,

*calycibus levibus* Hall. Enum. 752, var.  $\beta$  *foliis laciniatis, costa lata, semipinnata, pinnis triangulis serratis*. *Sonchus oleraceus* var.  $\gamma$  *asper* L. Sp. 794. *Sonchus asper* Hill; Bischoff, Beitr. 221.—Syme, Engl. Bot. v, t. 811; Hegi, Ill. Fl. vi, pars 2, 1109, fig. 789; R. 309; Dr. 692.—F. 383.

262 A. *Lactuca agrestis*, 157 v., excl. ic. et planta e Brema Saxoniae; Annot. Diosc. 45 v., partim. *Lactuca sylvestris Cordi ac Tragi* Th. 75, partim; Sch. 22. *Lactuca sylvestris costa spinosa* C.B.P. 123 b; J. 32; S. 16. *Lactuca foliis semipinnatis, costa spinosa* Hall. Enum. 756. *Lactuca virosa* L. Sp. 795, var.  $\delta$ . *Lactuca Scariola* L. Sp. ed. 2, 1119.—Hayne, Arzn. Gewächse, i, t. 46; Dietr. Fl. Boruss. x, t. 663; R. 310; Dr. 691.—F. 171.

*Thalius* (loc. cit.) apparently did not distinguish this from the following species.

262 B. *Lactuca agrestis*, 157 v., quoad ic. et plantam e Brema Saxoniae tantum; Annot. Diosc. 45 v., partim. *Lactuca sylvestris Cordi ac Tragi* Th. 75, partim. *Lactuca sylvestris odore viroso* C.B.P. 123 b. *Lactuca foliis superioribus dentatis, costa spinosa* Hall. Enum. 757. *Lactuca virosa* L. Sp. 795, var.  $\alpha$ . *Lactuca virosa* L. Sp. ed. 2, 1119.—Hayne, Arzn. Gewächse, i, t. 47; Dietr. Fl. Boruss. x, t. 664; B.T. iii, t. 160; P.C. 162; L.P. 227; R. 309; Dr. 691.—Br. 148; Tr. 268!

263. *Smyrniium seu Angelica*, 158 r., cum ic.; Annot. Diosc. 55 v. *Angelica sativa* C.B.P. 155 a; C. 306; J. 48; S. 23. *Angelica Archangelica* L. Sp. 250. *Archangelica officinalis* Hoffm.—Hayne, Arzn. Gewächse, vii, t. 8; Dietr. Fl. Boruss. xii, t. 845; P.C. 10; L.P. 139; R. 541; Dr. 494; H. 5.—Br. 272; F. 68; Tr. 421!

264. *Solanum nigrum*, 158 v., sine ic. *Solanum vulgare seu Solatrum* Annot. Diosc. 67 r. *Solanum hortense, seu Solanum nigrum Cordi* Th. 106; Sch. 30. *Solanum Officinarum* C.B.P. 166 a; C. 308; J. 53; S. 26. *Solanum nigrum* var.  $\alpha$  *vulgare* L. Sp. 186. *Solanum nigrum* L. em. Mill. Gard. Dict. ed. 8, no. 1.—Hayne, Arzn. Gewächse, ii, t. 40; L.P. 246; R. 461; Dr. 591; H. 251.—Br. 102; F. 392.

\*265. *Solanum puniceum*, 158 v., sine ic. *Solanum Officinarum* var. *acinis puniceis* C.B.P. 166 a. *Solanum miniatum* Bernh. ex Willd. Enum. i, 236 (1809); Dunal in DC. Prodr. xiii, pars 1, 56; Martens u. Kemmler, Fl. Württemb. ed. 2, 379.—*Solanum puniceum* Gmel. Fl. Bad. Alsat. iv, 176 (1826).—Dietr. Fl. Boruss. x, t. 670; R. 461; Dr. 591.

Said to differ from the preceding in the somewhat rougher branchlets and the colour of the berries ('*acinosque in croceo colore puniceos producat*'). These characters point to *S. miniatum*.

266. *Xanthion*, 158 v., ic. 159 r.; Annot. Diosc. 72 v. *Lappa minor, Xanthium Dioscoridis* C.B.P. 198 b; C. 460; J. 67; S. 32. *Xanthium strumarium* L. Sp. 987.—Plenck, Ic. Pl. Med. vii, t. 667; Dietr. Fl. Boruss. xi, t. 764; L.P. 76; R. 273; Dr. 669.—Br. 155; F. 329; Tr. 839!

267. *Hippia minor*, 159 r., cum ic. *Alsine media* C.B.P. 250 b. *Alsine pentastemon*, *petalis bipartitis* Hall. Enum. 386. *Alsine media* L. Sp. 272. *Stellaria media* (L.) Vill.—Syme, Engl. Bot. II, t. 229; P.C. 68; R. 697; Dr. 208.—Br. 234; F. 10; Tr. 385!

The specimens in C. Bauhin's and Burser's herbaria have been identified as *Arenaria trinervia* L. (C. 471; S. 45).

268. *Calcatrippa candida*, 159 v., cum ic. *Consolida regalis* Th. 28; Sch. 28. *Consolida regalis hortensis flore minore* C.B.P. 142 a. *Delphinium Consolida* L. Sp. 530.—Dietr. Fl. Boruss. v, t. 336; P.C. 160; R. 614; Dr. 227.—Br. 21; F. 15; Tr. 569!

The specimen in C. Bauhin's and Burser's herbaria have been identified as *D. Ajacis* L. (C. 303; S. 20).

\*269. *Daucoides maius*, 159 v., sine ic.; Th. 35. *Tordylium maximum* L. Sp. 240.—Jacq. Fl. Austr. II, 26, t. 142; Dietr. Fl. Boruss. XI, t. 746; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxvii, t. 2809; Hegi, Ill. Fl. v, pars 2, 1462, fig. 2558.

The description of the basal leaves as resembling those of *Daucus Selinoides* (*Pimpinella saxifraga*) and being hirsute, the height of the stem 'sesquicubitalis, aut aliquandum maior' (say, 2-3 ft.), the reddish-white flowers, and the subrotund 'seeds', rough like burs, and adhering to the clothes, suggest *Tordylium maximum*.

Identified by Dierbach (Beitr. Deutschl. Fl. I, 113: 1825) as *Turgenia latifolia* (L.) Hoffm.

\*270. *Daucoides minus*, 159 v., sine ic.; Th. 35; Sch. 14. *Caucalis semine aspero flosculis rubentibus* C.B.P. 153 a; C. 306; J. 46; S. 22. *Tordylium Anthriscus* L. Sp. 240. *Caucalis Anthriscus* (L.) Huds. Fl. Angl. 99 (1762). *Torilis Anthriscus* (L.) C. C. Gmel. Fl. Bad. I, 615 (1806); non Gaertn. (1788). *Torilis rubella* Moench, Meth. 103 (1794).—Jacq. Fl. Austr. III, t. 261; Hayne, Arzn. Gewächse, I, t. 36; Dietr. Fl. Boruss. x, t. 700; Reichb. Ic. Fl. Germ. XXI, t. 2006.

Identified by Dierbach (loc. cit.) as *Caucalis daucoides* L.

\*271 A. *Conyza sylvestris hirsuta*, 160 r., excl. ic. *Aster luteus hirsuto Salicis folio* C.B.P. 266 b; J. 98; S. 49. *Inula hirta* L. Sp. 883.—Reichb. Ic. Fl. Germ. xvi, t. 927; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxix, t. 2988; Hegi, Ill. Fl. vi, pars 1, t. 262, fig. 2; R. 270; Dr. 666.

Identified as *Inula hirta* by a process of exclusion. The capitula are described as rough (*aspera*) beneath, and as resembling those of *Conyza campestris* (probably *Pulicaria dysenterica*), but having longer ray florets. The habitat 'nascitur incultis, montanis et frutetosis locis' is consistent with *I. hirta*.

271 B. *Conyza Tragi*, 160 r., ic. sinistr. *Conyza major flore globoso* C.B.P. 266 a; C. 723; J. 97; S. 48. *Inula Pulicaria* L. Sp. 882; Willd. Sp. Pl.

III, 2093. *Pulicaria vulgaris* Gaertn.—Dietr. Fl. Boruss. VIII, t. 562; Hegi, Ill. Fl. VI, pars 1, 488, fig. 246; R. 270; Dr. 667.—Tr. 166!—vide no. 247 B.

271 C. [*Tertia Solidaginis Sarracenicae species Tragi*] 160 r., ic. dextr. *Conyzae affinis Germanica* C.B.P. 266 b; J. 98; S. 49. *Inula germanica* L. Sp. 883.—Jacq. Fl. Austr. II, 21, t. 134; Reichb. Ic. Fl. Germ. XVI, t. 931, fig. II.; Hegi, Ill. Fl. VI, pars 1, 478, fig. 242; R. 270; Dr. 666.—Tr. 488!

272. *Conyza sylvestris glabra*, 160 r., sine ic. *Aster montanus luteus Salicis glabro folio* C.B.P. 266 b; C. 723; J. 98; S. 49. *Inula salicina* L. Sp. 882.—Dietr. Fl. Boruss. XII, t. 808; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XXIX, t. 2986; Hegi, Ill. Fl. VI, pars 1, t. 262, fig. 1; R. 269; Dr. 666.

Described as resembling *Conyza sylvestris hirsuta* (*Inula hirta*), from which it differs in the glabrous stem and leaves and in the capitula which are not so rough and hirsute. These are characters in which *Inula salicina* differs from *I. hirta*.

273 A. *Conyza Helenitis*, 160 v., excl. ic. *Conyzis affinis* C.B.P. 265 b; C. 722; J. 97. *Inula Britannica* L. Sp. 882.—Zenker, Fl. Thüringen, VI, t. 681; Dietr. Fl. Boruss. VII, t. 495; Reichb. Ic. Fl. Germ. XVI, t. 926; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XXIX, t. 2991; R. 269; Dr. 666.

Described as resembling *Inula Helenium* in leaves, stems, capitula, and taste, but as being much smaller. The description fits *Inula Britannica* better than *Pulicaria dysenterica*, the size of the basal leaves, 3–4 inches long, 1 inch broad, the slender, simple or sometimes branched stem, the outer florets about an inch long ('stamina, florem constituentia, longitudine plerumque unciali') being characters in favour of *I. Britannica*. *Pulicaria dysenterica* was apparently *Conyza campestris* V. Cord.—vide no. 271 A.

273 B. *Conyza Helenitis*, 160 v., quoad ic. tantum. *Conyza helenitis* Cordi Th. 21; Sch. 10. *Conyza major vulgaris* C.B.P. 265 a; J. 97; S. 48. *Conyza foliis ovato-lanceolatis, floribus laxo umbellatis* Hall. Enum. 704. *Conyza squarrosa* L. Sp. 861. *Inula Conyza* DC.—Dietr. Fl. Boruss. XI, t. 772; Hegi, Ill. Fl. VI, pars 1, t. 262, fig. 3; R. 269; Dr. 665.

274 A. *Chamaeclema*, 161 r., excl. ic., 160 v. *Gundelrebe* Annot. Diosc. 71 v., cap. 126. *Hedera terrestris vulgaris* C.B.P. 306 a; C. 730; J. 114; S. 57. *Glechoma hederacea* L. Sp. 578.—Hayne, Arzn. Gewächse, II, t. 8; Dietr. Fl. Boruss. II, t. 117; P.C. 122; L.P. 202; R. 416; Dr. 573.—Br. 56; F. 500.

274 B. *Chamaeclema*, 160 v., quoad ic. tantum. *Genista tinctoria Germanica* C.B.P. 395 b; C. 743; J. 143; S. 72. *Genista foliis confertis, ovalibus, acutis, floribus sessilibus, spicatis* Hall. Enum. 592. *Genista tinctoria* L. Sp. 710.—Nees, Pl. Med. II, t. 323; Syme, Engl. Bot. III, t. 328; Lindm. Bild. Nord. Fl. II, t. 332; P.C. 95; R. 985; Dr. 311.—F. 460; Tr. 604! (*Ferula*).

275. *Parthenium*, 161 r., cum ic. ; Annot. Diosc. 59 v. ; Th. 92. *Matricaria vulgaris* C.B.P. 133 a ; C. 301 ; J. 39 ; S. 19. *Matricaria foliis pinnatis, pinnis latis, incis, semiflosculis brevissimis* Hall. Enum. 719. *Matricaria Parthenium* L. Sp. 890. *Chrysanthemum Parthenium* (L.) Bernh.—Regn. Bot. II, t. 153 ; Hegi, Ill. Fl. VI, pars 2, 617, fig. 330 ; P.C. 104 ; R. 283 ; Dr. 676.—Br. 86 ; F. 25 ; Tr. 156 !

276. *Tribulus lacustris*, 161 v., cum ic. *Tribulus aquaticus* Annot. Diosc. 62 r. *Tribulus aquaticus* C.B.P. 194 a ; C. 459 ; S. 32. *Tribuloides* Hall. Enum. 468. *Trapa natans* L. Sp. 120.—Regn. Bot. II, t. 22 ; Hegi, Ill. Fl. v, pars 2, t. 190, fig. 1 ; R. 910 ; Dr. 483.—Tr. 841 !

277. *Cicuta maior*, 162 r., cum ic. *Cicuta* Annot. Diosc. 68 r. *Cicuta vera* Th. 33 ; Sch. 13. *Cicuta major* C.B.P. 160 a ; C. 307 ; J. 50 ; S. 24. *Cicuta* Hall. Enum. 434. *Conium maculatum* L. Sp. 243.—Regn. Bot. II, t. 49 ; Jacq. Fl. Austr. II, t. 156 ; Hayne, Arzn. Gewächse, I, t. 31 ; B.T. 118 ; P.C. 130 ; L.P. 253 ; R. 556 ; Dr. 487.—F. 230 ; Tr. 474 !

The figure in Tragus, which is hardly recognizable as *Conium maculatum*, is obviously copied from the bad but recognizable one in Fuchs, Hist. 406.

278. *Cicuta minor*, 162 r., sine ic. *Species Cicutae . . . in arcis hortorum* Annot. Diosc. 68 r. *Cicuta minor petroselino similis* C.B.P. 160 b ; C. 307 ; J. 50 ; S. 24. *Ethusa* Hall. Enum. 433. *Aethusa Cynapium* L. Sp. 256.—Plenck, Ic. Pl. Med. III, t. 202 ; Hayne, Arzn. Gewächse, I, t. 35 ; Dietr. Fl. Boruss. IX, t. 647 ; B.T. 125 ; P.C. 108 ; R. 536 ; Dr. 491.

\*279 A. *Pneumonanthes caule ramoso*, 162 v., excl. ic. *Gentiana autumnalis ramosa* C.B.P. 188 b, partim ; C. 311 ; J. 63. *Gentiana foliis amplexicaulibus, floris fauce barbata* Hall. Enum. 473, partim. *Gentiana faucibus barbatis, calycis segmentis quinis, aequalibus* Hall. Hist. I, 289. *Calathiana punicea* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. II, 45, t. 21, no. 87 (1770). *Gentiana germanica* Willd. Sp. Pl. I, 1346 ; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. xxx, 61 (1916).—Dietr. Fl. Boruss. IV, t. 234 ; Fl. Dan. Suppl. t. 67 ; Schlecht. Langeth. u. Schenck, Fl. Deutschl. XVI, t. 1563 ; R. 387 ; Dr. 530.

The statement that the flowers are like those of Modelger [*Gentiana cruciata*], but larger, excludes *Gentiana Amarella* L., to which the description was referred by Dierbach (Beitr. Deutschl. Fl. III, 11 : 1830). Thalius, Sylv. Hercyn. 130 (1588), referred *Pneumonanthe* Cord. to his *Viola calathiana seu autumnalis prima*, which is *Gentiana ciliata* L. according to E. Schulze (1905, 35).

279 B. *Pneumonanthes caule singulari*, 162 v., cum ic. *Gentiana angustifolia autumnalis major* C.B.P. 188 b, partim ; C. 311 ; J. 63 ; S. 30. *Gentiana foliis longis et angustis, floribus in alis caulibus sessilibus* Hall. Enum. 477. *Gentiana alis floriferis, foliis linearibus* Hall. Hist. I, 285. *Gentiana Pneumonanthe* L. Sp. 228 ; Willd. Sp. I, 1336.—Dreves et Hayne, Choix Pl. Eur. t. 79 ; Dietr. Fl. Boruss. II, t. 73 ; Reichb. Ic. Fl. Germ. XVII, t. 1051, fig. 2 ; R. 386 ;



Dr. 530.—*Viola calathiana* Dod. Stirp. Hist. Comment. Imag. i, 212 (1559). *Gentianella palustris foemina* Gesn. Op. Bot. ed. Schmidel, II, 20, t. 26, no. 90 (1770)! *Gentianella cruciata palustris angustioribus foliis* Gesn. loc. cit. 50, t. 28, no. 91.

280. *Colchicum nigrum*, 162 v., ic. 163 r.; *Colchicum* Annot. Diosc. 68 v. *Colchicum commune* C.B.P. 67 a; J. 20. *Colchicum* Hall. Enum. 283. *Colchicum autumnale* L. Sp. 341.—Hayne, Arzn. Gewächse, v, t. 45; Dietr. Fl. Boruss. i, t. 30; Hegi, Ill. Fl. II, t. 58, fig. 3; B.T. 288; P.C. 76; L.P. 258; R. 84; Dr. 114.—Br. 176; F. 203, 204; Tr. 759!

281. *Colchicum subrubens*, 163 v., sine ic. *Colchicum commune* C.B.P. 67 a. *Colchicum* Hall. Enum. 283, var.  $\beta$ . *Colchicum autumnale* L.

Apparently only a form of *C. autumnale* with reddish-tinged corms.

282. *Colchicum album*, 163 v., sine ic. *Colchicum radice siccata alba* C.B.P. 67 b. *Colchicum* Hall. Enum. 283, var.  $\gamma$ . *Colchicum* sp.

Never seen growing spontaneously in Germany by Cordus, but only cultivated and imported from remote places. Various species of *Colchicum* besides *C. autumnale* are mentioned as being employed medicinally, or as containing Colchicin, in Rosenthal, Syn. Pl. Diaphor. 85, Dragendorff, Heilpfl. 114, 115, and Tschirch, Handb. Pharmakogn. III, 134, 137.

283. *Crocus*, 163 v., cum ic.; Annot. Diosc. 9 r. *Crocus sativus* C.B.P. 65 a; J. 19; S. 11. *Crocus sativus* var. *officinalis* L. Sp. 36. *Crocus sativus* Hall. Hist. II, 127 (1768). *Crocus sativus* L. emend. Mill. (1768).—Hayne, Arzn. Gewächse, VI, t. 25; Reichb. Ic. Fl. Germ. IX, t. 360, fig. 798, 799; B.T. 274; P.C. 243; L.P. 184; R. 111; Dr. 139; H. 172.—F. 250; Tr. 763!

284 A. *Glycyrrhiza*, 164 r., excl. ic. *Dulcis radix* Annot. Diosc. 50 r. *Glycyrrhiza siliquosa vel Germanica* C.B.P. 352 a; J. 132; S. 66. *Glycyrrhiza glabra* L. Sp. 742.—Hayne, Arzn. Gewächse, VI, t. 42; Köhler, Med. Pfl. I, t. 85; B.T. 74; P.C. 168; L.P. 193; R. 997; Dr. 319; H. 97.—Br. 182; F. 107.

284 B. *Glycyrrhiza*, 164 r., quoad ic. tantum. *Glycyrrhiza glabra* L. var. *glandulifera* Reg. et Herd.; Boiss. Fl. Or. II, 202.—Sibth. Fl. Graec. t. 709; Waldst. et Kit. Ic. Pl. Hung. I, t. 21; R. 998; Dr. 319; H. 98.—Tr. 935!

285. *Vetonica*, 164 v., ic. 165 r.; Annot. Diosc. 61 r. *Betonica purpurea* C.B.P. 235 a; C. 468; J. 83; S. 41. *Betonica foliis inter verticillos in vertice congestos brevissimis et integris* Hall. Enum. 646. *Betonica officinalis* L. Sp. 573. *Stachys officinalis* (L.) Trevisan.—Hayne, Arzn. Gewächse, IV, t. 10; Dietr. Fl. Boruss. XI, t. 783; P.C. 304; L.P. 211; R. 419; Dr. 576.—Br. 23; F. 199; Tr. 198!

• 286. *Elleborus albus*, 165 r., cum ic. *Veratrum album* Annot. Diosc. 73 v. *Helleborus albus flore subviridi* C.B.P. 186 b; J. 62; S. 30. *Veratrum* Hall. Enum. 298. *Veratrum album* L. Sp. 1044.—Jacq. Fl. Austr. IV, t. 335;

Hayne, Arzn. Gewächse, XIII, t. 26 ; B.T. 285 ; L.P. 261 ; R. 83 ; Dr. 113 ; H. 75.—F. 153 ; Tr. 409 !

287. *Vetonica alba*, 165 v., sine ic. *Betonica alba* C.B.P. 235 b ; C. 468. *Betonica officinalis* L. Sp. 573, var.  $\beta$ . *Stachys officinalis* (L.) Trevisan, flore albo.—Br. 210.

288. *Halicacabus sive Vesicaria*, 165 v., ic. 166 r. *Vesicaria* Annot. Diosc. 67 r. *Solanum vesicarium, quod folliculi vesicae inflatae similes* C.B.P. 166 a ; C. 308 ; J. 54 ; S. 26. *Alkekengi foliis cordatis, calyce rubente* Hall. Enum. 508. *Physalis Alkekengi* L. Sp. 183.—Plenck, Ic. Pl. Med. II, t. 124 ; Sibth. Fl. Graec. III, t. 234 ; P.C. 303 ; L.P. 54 ; R. 455 ; Dr. 596.—Br. 237 ; F. 393 ; Tr. 302 !

289. *Cnicus supinus*, 166 r., cum ic. *Acanthium* Annot. Diosc. 51 r. *Cnicus sylvestris hirsutior, sive Carduus benedictus* C.B.P. 378 b ; J. 139 ; S. 70. *Cnicus benedictus* L. Sp. 826.—Hayne, Arzn. Gewächse, VII, t. 34 ; Reichb. Ic. Fl. Germ. xv, t. 748 ; Köhler, Med. Pfl. I, t. 53 ; P.C. 133 ; L.P. 117 ; R. 299 ; Dr. 689.—F. 67 ; Tr. 862 !

290. *Faba vulgaris*, 166 v., cum ic. *Faba* Annot. Diosc. 43 r. *Faba* C.B.P. 338 a ; J. 126 ; S. 63. *Vicia Faba* L. Sp. 737.—Plenck, Ic. Pl. Med. VI, t. 560 ; Hayne, Arzn. Gewächse, XI, t. 48 ; L.P. 65 ; R. 1006 ; Dr. 330.—Br. 222 ; F. 220 ; Tr. 618 !

A form of the broad bean, about 2 ft. 9 in. high, with 5–8 seeds in each pod, cultivated as a field crop.

291. *Faba nigra minor*, 166 v., sine ic. ; C.B.P. 338 a, sub *Faba*, in obs. *Vicia Faba* L.

A small form of the broad bean, cultivated in gardens, with blackish-purple seeds.

292. *Faba nigra maior*, 166 v., sine ic. ; C.B.P. 338 a, sub *Faba*, in obs. *Vicia Faba* L.

A large form of the broad bean, cultivated in gardens, with blackish-purple seeds 1 in. long or more.

293. *Symphyton maius*, 167 r., cum ic. *Alterum Symphytum* Annot. Diosc. 62 r. *Symphytum Consolida major* C.B.P. 259 a ; C. 474 ; J. 94 ; S. 47. *Symphytum foliis ovato lanceolatis, caule alato* Hall. Enum. 514, var.  $\alpha$ . *Symphytum officinale* L. Sp. 136, var. *ochroleucum* DC. in DC. Prodr. x, 37.—Fl. Dan. IV, t. 664 ; Zenker, Fl. Thüringen, II, t. 153 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XIX, t. 1898 ; P.C. 78 ; L.P. 102 ; R. 438 ; Dr. 562 ; H. 37.—Br. 19 ; F. 397 ; Tr. 240 !

294. *Symphyton maius rubens*, 167 v., sine ic. *Symphytum foliis ovato lanceolatis, caule alato* Hall. Enum. 514, var.  $\beta$ . *Symphytum officinale* L., var. *purpureum* Pers. ; DC. in DC. Prodr. x, 37.—Sweet, Brit. Fl. Gard. VII, t. 304.

295. *Symphytum maius purpureum*, 167 v., sine ic. *Symphytum foliis ovato lanceolatis, caule alato* Hall. Enum. 514, var.  $\beta$ . *Symphytum officinale* var. *purpureum* Pers. ; DC. in DC. Prodr. x, 37.—Svensk Bot. vi, t. 418.

296. *Onicus sativus*, 167 v., cum ic. ; Annot. Diosc. 76 r. *Onicus sativus* sive *Carthamus officinarum* C.B.P. 378 a ; J. 139 ; S. 70. *Carthamus tinctorius* L. Sp. 830.—Plenck, 1c. Pl. Med. vi, t. 600 ; Schlecht. Langeth. u. Schenck, Fl. Deutschl. ed. 5, xxx, t. 3154 ; P.C. 242 ; R. 299 ; Dr. 688 ; H. 171.—Br. 196, 282 ; F. 232 ; Tr. 845 !

297. *Amarantus* sive *Amarantus purpureus*, 168 r., cum ic. *Purpurea Amaranthus* Annot. Diosc. 65 v., cap. 57. *Amaranthus simplicis panicula* C.B.P. 121 a. *Celosia margaritacea* L. Sp. ed. 2, 297. *Celosia argentea* var. *margaritacea* (L.) Moq. in DC. Prodr. xiii, pars 2, 243 ; Voss in Vilmorin's Blumengärtnerei, ed. 3, i, 864 (1895).—R. 217 ; Dr. 201.—F. 54 ; Tr. 579 !

The figure, taken from Tragus, is copied from the one in Fuchs, Historia, 100, previously identified (F. 54) as *Celosia cristata* L. ; the latter appears to be only an abnormal derivative of *C. argentea* var. *margaritacea*.

298. *Apium sativum*, 168 r., ic. 168 v. ; Annot. Diosc. 55 r. *Apium palustre*, et *Apium Officinarum* C.B.P. 154 a ; J. 47. *Apium graveolens* L. Sp. 264 (forma culta).—P.C. 63 ; L.P. 42 ; R. 528 ; Dr. 487.—Br. 174 ; F. 426 ; Tr. 464 !

299. *Apium agreste*, 168 v., sine ic. *Apium [quae] sponte nascitur* Annot. Diosc. 55 r. *Apium palustre*, et *Apium Officinarum* C.B.P. 154 a ; J. 47 ; S. 23. *Apium foliis semitrifidis, ora loborum circumserrata* Hall. Enum. 427. *Apium graveolens* L. Sp. 264 (forma spontanea).—Dietr. Fl. Boruss. xii. t. 810.—Br. 174 ; F. 426.

300. *Eupatorium*, sive *Agrimonia*, 168 v., ic. 169 r. ; Annot. Diosc. 64 r. *Eupatorium veterum* sive *Agrimonia* C.B.P. 321 b ; C. 733 ; J. 119 ; S. 59. *Agrimonia foliis pinnatis fructibus hispidis* Hall. Enum. 407. *Agrimonia Eupatoria* L. Sp. 448.—Dietr. Fl. Boruss. vi, t. 410 ; P.C. 5 ; L.P. 97 ; R. 963 ; Dr. 280.—Br. 160 ; F. 137 ; Tr. 514 !

301. *Eupatorium alterum*, 169 r., sine ic. *Quinquefolium rectum luteum* C.B.P. 325 b ; C. 734 ; J. 120 ; S. 60. *Potentilla recta* L. Sp. 497 ; Dierbach, Beitr. Deutschl. Fl. i, 7 ; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. xxxiii, 57 (1916).—Dietr. Fl. Boruss. iv, t. 238.—Br. 103 (var. *obscura* Koch).

The description agrees better with *Potentilla recta* than with *P. canescens* Bess., to which it was referred tentatively by Schlechtendal in Ber. Sitz. Naturf. Ges. Halle, 1856, 20. The latter has the leaflets greyish tomentose beneath.

302. *Filix mascula*, 169 r., excl. ic. 169 v. *Filix* Annot. Diosc. 76 r. *Filix non ramosa dentata* C.B.P. 358 a ; J. 133 ; S. 67. *Polypodium fronde duplicato pinnata, foliolis obtusis crenatis, petiolo strigoso* Hall. Enum. 139. *Polypodium*

*Filix-mas* L. Sp. 1090. *Nephrodium Filix-mas* (L.) Rich. *Aspidium Filix-mas* (L.) Sw. *Dryopteris Filix-mas* (L.) Schott.—Hook. Brit. Ferns, t. 15; Bonnier, Fl. Compl. t. 707, fig. 3285; B.T. 300; P.C. 177; L.P. 23; R. 45; Dr. 54.—F. 338; Tr. 546!

Judging from the extremely wide range of habitats given by Cordus—‘nascitur montanis saxosis et umbrosis locis, copiosaque etiam in planis uliginosisque locis, juxta aquas ac profluentes Alnorum, reliquarum arborum truncis et radicibus adnascens’—it seems probable that he confused other ferns with *D. Filix-mas*. Thalius (Sylv. Hercyn. 42: 1588) mentioned three kinds of *Filix-mas*, the two others being *Athyrium Filix-femina* (L.) Roth and *Polystichum lobatum* (Huds.) Presl, according to E. Schulze (1905, 15).

The figure, taken from Tragus, is unidentifiable.

\*303. *Pteridion masculum*, 169 v., sine ic. *Polypodium pinnatum*, pinnis lanceolatis pinnatifidis, integris, inferioribus nutantibus Hall. Enum. 138. *Polypodium Phegopteris* L. Sp. 1089; Willd. Sp. v, 199. *Phegopteris polypodioides* Fée. *Dryopteris Phegopteris* (L.) C. Chr.—Hook. Brit. Ferns, t. 3; Lowe, Our Native Ferns, I, t. 1; Schlecht. Langeth. u. Schenk, Fl. Deutschl. I, t. 13; Bonnier, Fl. Compl. XII, t. 702, fig. 3275.

Described as resembling *Filix mascula* (*Dryopteris Filix-mas*), but much smaller, with more elegantly cut fronds.

304. *Pteriadion*, 170 r., sine ic. *Adiantum foliis longioribus pulverulentis pediculo nigro* C.B.P. 355 b; J. 133; S. 67. *Adiantum nigrum Officinarum* J. Bauh. Hist. III, 742 b. *Asplenium ramis ramosis, confertis, sursum decrescentibus* Hall. Enum. 136. *Asplenium Adiantum-nigrum* L. Sp. 1081.—Nees, Pl. Offic. I, t. 16; Hook. Brit. Ferns, t. 33; Bonnier, Fl. Compl. XII, t. 709, fig. 3289; P.C. 204; R. 45; Dr. 56.

Described by Cordus as being similar to *Pteridion masculum* (*Dryopteris Phegopteris*), but generally a little smaller, the cutting of the fronds being intermediate between those of that species and *Adiantum candidum* (*Asplenium Ruta-muraria*), and the rhaches of the fronds being black and glossy. The habitat was on shady mossy and dewy rocks. These details suggest *Asplenium Adiantum-nigrum*, and seem to exclude all other ferns indigenous in Germany. It is noteworthy that *Pteriadion* Cord. was referred tentatively to that species (as *Adiantum nigrum Officinarum*) by Jean Bauhin, Hist. III, 742 b (1651).

305. *Trichomanes*, 170 r., ic. superior; Annot. Diosc. 72 v. *Trichomanes sive Polytrichum officinarum* C.B.P. 356 a; J. 133; S. 67. *Asplenium fronde pinnata foliolis subrotundis crenatis* Hall. Enum. 135. *Asplenium Trichomanes* L. Sp. 1080; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. XXXIII, 49 (1916).—Curt. Fl. Lond. ed. 2, v, t. 156 (K. 9); Hook. Brit. Ferns, t. 29; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, I, t. 26; Syme, Engl. Bot. XII, t. 1878; L.P. 204; R. 45; Dr. 56.—*Trichomanes, officinis Polytrichon* Tr. 530!

306. *Pteridion foemina*, 170 v., cum ic. *Dryopteris* Annot. Diosc. 76 r. *Dryopteris Tragi* Th. 38. *Filix querna* C.B.P. 358 a ; J. 133 ; S. 67. *Polypodium pinnis ramorum pinnatis, pinnulis confertis, oblongis, integerrimis* Hall. Enum. 141. *Polypodium Dryopteris* L. Sp. 1093 ; Willd. Sp. v. 209. *Phegopteris Dryopteris* (L.) Fée. *Dryopteris Linnaeana* C. Chr.—Hook. Brit. Ferns, t. 4 ; Lowe, Our Native Ferns, I, 15, t. 4 ; Bonnier, Fl. Compl. XII, t. 702, fig. 3276 ; Dr. 58.—Tr. 538 !

Described as resembling *Thelypteris* (*Pteridium aquilinum*), but much smaller. *Dryopteris Phegopteris* and *D. Linnaeana* are the only pair of related ferns which can be described as resembling small editions of *Dryopteris Filix-mas* and *Pteridium aquilinum* respectively. Hence the identifications of nos. 303 and 306 are mutually confirmatory.

\*307 A. *Struthiopteris*, 171 r., excl. ic. 170 v. *Struthiopteris Cordi* Th. 119 ; Sch. 33. *Filix palustris altera subfusco pulvere hirsuta* C.B.P. 358 a ; J. 133 ; S. 67. *Struthiopteris* Hall. Enum. 132, var.  $\gamma$ . *Osmunda Struthiopteris* L. Sp. 1066. *Onoclea Struthiopteris* (L.) Hoffm. *Struthiopteris germanica* Willd. ; Aug. Schulz in Mitt. Thüring. Bot. Ver. N.F. xxxiii, 49 (1916). *Matteuccia Struthiopteris* (L.) Todaro.—Fl. Dan. I, t. 169 ; Lowe, Ferns, II, t. 63 ; Britten, Eur. Ferns, I ; Schlecht. Langeth. u. Schenck, Fl. Deutschl. ed. 5, I, t. 55 ; Bonnier, Fl. Compl. XII, t. 713, fig. 3302 ; Dr. 56.

Cordus knew only the fertile fronds of the Ostrich fern, not having seen the plant growing. His description of them as resembling ostrich feathers in their general appearance and curled condition, and the statement that the pinnae are divided into transverse segments, clearly indicate *Matteuccia Struthiopteris* and exclude *Blechnum Spicant*.

307 B. *Struthiopteris*, 170 v., quoad ic. tantum. *Lonchitis minor* C.B.P. 359 a ; J. 134 ; S. 67. *Struthiopteris* Hall. Enum. 132. *Osmunda Spicant* L. Sp. 1066. *Lomaria Spicant* (L.) Desv. *Blechnum boreale* (Salisb.) Sw. *Blechnum Spicant* (L.) Withering.—Curt. Fl. Lond. ed. 2, II, fasc. i, t. 10 ; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, I, t. 22 ; Hook. Brit. Ferns, t. 40 ; Lowe, Our Native Ferns, II, 379, t. 58 ; Britten, Eur. Ferns, frontispiece ; R. 44 ; Dr. 56.—Tr. 550 !

308. *Polypodium*, 171 r., ic. 171 v. ; Annot. Diosc. 76 r. *Polypodium vulgare* C.B.P. 359 a ; J. 134 ; S. 67. *Polypodium pinnatum, pinnis lanceolatis integris* Hall. Enum. 137. *Polypodium vulgare* L. Sp. 1085.—Nees, Pl. Offic. I, t. 15 ; Hook. Brit. Ferns, t. 2 ; P.C. 224 ; L.P. 13 ; R. 42 ; Dr. 57.—Br. 175 ; F. 334 ; Tr. 540 !

309. *Scolopendrium, sive Asplenon* 171 v., cum ic. *Asplenon* Annot. Diosc. 59 v. *Ceterach officinarum* C.B.P. 354 a ; J. 132 ; S. 67. *Asplenium fronde pinnatifida laciniis alternis adnatis* Hall. Enum. 135. *Asplenium Ceterach* L. Sp. 1080. *Ceterach officinarum* DC.—Hayne, Arzn. Gewächse, VIII, t. 48 ; Hook. Brit. Ferns, t. 36 ; Lowe, Our Native Ferns, II, 371, t. 57 ; R. 41, 1071 ; Dr. 57.—Tr. 551 !

310. *Adiantum candidum*, 171 v., 172 r., ic. sinistr. inferior; Annot. Diosc. 72 v. *Ruta muraria* C.B.P. 356 a; J. 133; S. 67. *Asplenium ramis duplicato ramosis, pinnis serratis, aequalibus, et laxè dispositis* Hall. Enum. 137. *Asplenium Ruta-muraria* L. Sp. 1081.—Zenker, Fl. Thüringen, iv, t. 361; Hook. Brit. Ferns, t. 28; R. 45; Dr. 56.—Br. 78; F. 417. *Capillus Veneris, seu Ruta muraria* Tr. 503!

311. *Adiantum nigrum*, 172 r., cum ic.; Annot. Diosc. 72 v. *Adiantum foliis coriandri* C.B.P. 355 a; J. 133; S. 67. *Adiantum Capillus-Veneris* L. Sp. 1096.—Nees, Pl. Offic. I, t. 17; Hook. Brit. Ferns, t. 41; P.C. 176; L.P. 204; R. 43; Dr. 53.—F. 45; Tr. 531!

312. *Moschatella*, 172 v., cum ic.; Th. 78; Sch. 23. *Ranunculus nemorosus Muscatellina dictus* C.B.P. 178 b; J. 58; S. 28. *Moscatellina* Hall. Enum. 412. *Adoxa Moscatellina* L. Sp. 367.—Svensk Bot. vii, t. 435; Dietr. Fl. Boruss. II, t. 105; R. 562; Dr. 643.—*eyn kreütlin . . . der auszgehülchten Holwurtzel . . . aenlich* Bock, New Kreütter Buoch, II, fol. lviii. v. (1539); *herbula . . . Aristolochiae rotundae concavae similis* Tr. 767.

313. *Oxys*, 173 r., ic. 172 v. *Trifolium acetosum vulgare* C.B.P. 330 a; C. 735; J. 123; S. 62. *Oxys radice dentata, foliis ternatis, scapo nudo, unifloro* Hall. Enum. 364. *Oralis Acetosella* L. Sp. 433.—Hayne, Arzn. Gewächse, v, t. 39; Dietr. Fl. Boruss. II, t. 131; P.C. 306; R. 894; Dr. 340; H. 192.—Br. 153; F. 320; Tr. 521!

314. *Fragula*, 173 r., ic. 173 v. *Fragaria vulgaris* C.B.P. 326 a; S. 60. *Fragaria flagellis reptans* Hall. Enum. 343. *Fragaria vesca* L. Sp. 494.—Hayne, Arzn. Gewächse, IV, t. 26; Dietr. Fl. Boruss. v, t. 318; P.C. 273; L.P. 95; R. 960; H. 197.—Br. 107; F. 488; Tr. 500!

*Liber III : Arborum, fructuum, et arbustorum  
descriptiones continens.*

315. *Ulmus*, 174 r., cum ic.; Annot. Diosc. 18 r. *Ulmus campestris et Theophrasti* C.B.P. 426 a; C. 744; J. 147. *Ulmus* spp. seq.: (1) *Ulmus campestris* L. Sp. 225, sensu Hegi, Ill. Fl. III, 119=*Ulmus nitens* Moench; (2) *Ulmus montana* With.=*U. scabra* Mill.=*U. glabra* Huds. em. Moss; (3) *U. effusa* Willd.=*U. laevis* Pall.=*U. pedunculata* Fouger.—R. 189; Dr. 170.

316. *Acer tenuifolia*, 174 v., cum ic. *Acer campestre et minus* C.B.P. 431 b; C. 745; J. 148. *Acer foliis semitrilobis, lobis obtuse incisissimis* Hall. Enum. 421. *Massholder Tragi* Gesn. Op., ed. Schmidel, II, Hist. Pl. fasc. 1, 16, t. 9, no. 19 (1759). *Acer campestre* L. Sp. 1055; Hegi, Ill. Fl. v, pars 2, 284.—Fl. Dan. viii, t. 1288; Guimpel, Willd. u. Hayne, Abbild, deutsch. Holzart. II, t. 213; Reichb. Ic. Fl. Germ. v, t. 162, fig. 4825; R. 771; Dr. 405; H. 107.—Tr. 1123!

Referred by Dierbach, Beitr. Deutschl. Fl. I, 42 (1825) to *Acer platanoides* L., but the comparison of the bark to that of *Ulmus* indicates rather *A. campestre*. The figure supplied by Gesner from Tragus is also *A. campestre*.

317. *Lycostaphylon foemina*, 174 v., loc. cit. 175 r. *Sambucus aquatica* Th. 111; Sch. 32. *Sambucus aquatica flore simplici* C.B.P. 456 b; C. 747; J. 152. *Opulus* Hall. Enum. 463. *Viburnum Opulus* L. Sp. 268.—Fl. Dan. iv, t. 661; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. i, t. 32; P.C. 86; R. 354; Dr. 641.—Tr. 1002!

318. *Cervispina*, 175 r., cum ic. *Rhamnus solutivus* Th. 102; Sch. 30. *Rhamnus catharticus* C.B.P. 478 b; C. 748; J. 157. *Rhamnus spinosus, foliis ovatis, acuminatis, serratis* Hall. Enum. 163. *Rhamnus catharticus* L. Sp. 193.—Plenck. Ic. Pl. Med. ii, t. 140; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. i, t. 13; Hayne, Arnz. Gewächse, v, t. 43; B.T. 64; P.C. 41; L.P. 4; R. 801; Dr. 413.—Tr. 979!

319. *Acer maior*, 175 v., cum ic.; Th. 6; Sch. 6. *Acer montanum candidum* C.B.P. 430 a; C. 745; J. 148. *Acer foliis quinquangulis, undique serratis* Hall. Enum. 421. *Acer maior* Gesn. Op., ed. Schmidel, i, 126, no. 163, ic. lign. lineat. t. 19, fig. 163 (1754); ii, Hist. Pl. fasc. 1, 15, t. 8, no. 18 (1759). *Acer Pseudo-Platanus* L. Sp. 1054.—Fl. Dan. ix, t. 1575; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. ii, t. 210; Reichb. Ic. Fl. Germ. v, t. 164, fig. 4829; R. 771; Dr. 405.—Tr. 1125!

320. *Sorbus torminalis*, 175 v., ic. 176 r.; Annot. Diosc. 24 v.; Th. 107; Sch. 31. *Mespilus Apii folio sylvestris non spinosa, sive Sorbus Torminalis* C.B.P. 454 a; C. 746; J. 151. *Crataegus folio septangulo, subtus subhirsuto* Hall. Enum. 354. *Sorbus torminalis* Gesn. Op., ed. Schmidel, ii, Hist. Pl. fasc. ii, 4, t. 15, no. 54, t. 17, no. 54 (1770). *Crataegus torminalis* L. Sp. 476. *Sorbus torminalis* (L.) Crantz.—Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. i, t. 80; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxv, t. 79; Hegi, Ill. Fl. iv, pars 2, 719, fig. 1047; R. 947; Dr. 276.—Tr. 1010!

321. *Sorbus aculeata*, 176 r., cum ic. *Mespilus Apii folio sylvestris spinosa, sive Oxyacantha* C.B.P. 454 a; C. 746; J. 151. *Crataegus spinosa, foliis obtusis, saepe trifidis* Hall. Enum. 354. *Crataegus Oxyacantha* L. Sp. 477, sensu lato (incl. *C. oxyacanthoides* Thuill. et *C. monogyna* Jacq.).—Jacq. Fl. Austr. iii, t. 292, ff. 1, 2; Hegi, Ill. Fl. iv, pars 2, 736, fig. 1060; P.C. 127; L.P. 158; R. 950; Dr. 273.—Tr. 984!

The figure, taken from Tragus, represents *C. monogyna* Jacq.

322. *Anonymus*, 176 r., ic. 176 v. *Euonymus Theophrasti, sive Anonymus Cordi* Th. 42; Sch. 15. *Euonymus vulgaris granis rubentibus* C.B.P. 428 a; C. 745; J. 148. *Euonymus foliis oblongo-ovatis* Hall. Enum. 423. *Euonymus europaeus* L. Sp. 197.—Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. i, t. 16; Reichb. Ic. Fl. Germ. vi, t. 309, fig. 5134; R. 791; Dr. 400.—Tr. 983!

• 323. *Pyrus urbana*, 176 v., ic. 177 r.; Annot. Diosc. 24 r. *Pyrus sativa* C.B.P. 439 a; J. 149. *Pyrus communis* L. Sp. 479.—Plenck, Ic. Pl. Med. iv,

t. 395 ; Duhamel, *Traité des Arbres*, ed. 2, vi, tt. 60–74 bis ; R. 946 ; Dr. 275.—Tr. 1045 !

Cordus described fifty different varieties of Pear cultivated in Germany.

324. *Malus*, 179 v., ic. 180 r. *Malus sylvestris* C.B.P. 433 a. *Pyrus Malus* L. Sp. 479. *Malus pumila* Mill. (*M. communis* Poir.).—Regn. Bot. iii, t. 115 ; Plenck, Ic. Pl. Med. iv, t. 394 ; Hayne, *Arzn. Gewächse*, iv, t. 46 ; Duhamel, *Traité des Arbres*, ed. 2, vi, tt. 46–55 ; R. 944 ; Dr. 274.—Br. 283 ; Tr. 1042 !

Cordus described thirty-one different varieties of Apple cultivated in Germany.

325. *Cotoneus*, *sine malus Cydonia*, 181 v., ic. 182 r. : Annot. Diosc. 23 v. *Mala cotonea minora* C.B.P. 434 a ; J. 148. *Mala cotonea majora* C.B.P. 435 a. *Pyrus Cydonia* L. Sp. 480. *Cydonia oblonga* Mill. (*C. maliformis* Mill., *C. vulgaris* Pers.).—Duhamel, *Traité des Arbres*, ed. 2, iv, t. 36 ; Guimpel, Willd. u. Hayne, *Abbild. deutsch. Holzart.* i, t. 81 ; Hayne, *Arzn. Gewächse*, iv, t. 47 ; B.T. 106 ; P.C. 233 ; L.P. 90 ; R. 943 ; Dr. 274 ; H. 155.—F. 213 ; Tr. 1039 !

326. *Citrus arbor*, 182 v., cum ic. *Medicum malum* Annot. Diosc. 24 r. *Malus medica* C.B.P. 435 a. *Citrus medica* L. Sp. 782 (Citron).—Duhamel, *Traité des Arbres*, ed. 2, vii, t. 22 ; Risso et Poiteau, *Orangers*, ed. 2, tt. 96–107 ; B.T. 53 ; R. 757 ; Dr. 359 ; H. 33.—Tr. 1032 !

The figure, taken from Tragus, is a composite one, covering Oranges, Citrons, and Lemons.

327. *Arangius*, *seu Citrius*, 183 r., sine ic. ; *Arangia* Annot. Diosc. 24 r., cap. 167. *Malus Arantia major* C.B.P. 436 a ; J. 149. *Citrus Aurantium* L. Sp. 782, and *Citrus sinensis* Osbeck.—Risso et Poiteau, *Orangers*, ed. 2, tt. 3–29, 30–52 ; B.T. 50, 51 ; P.C. 202, 203 ; R. 761 ; Dr. 357 ; H. 127.—*Pomum arantium* Tr. 1035.

*Arangius* Cord. included both the Bitter Orange (*Citrus Aurantium*) and the Sweet Orange (*C. sinensis*).

328. *Limon*, 183 r., sine ic. *Limones* Annot. Diosc. 24 r., cap. 167. *Malus Limonia acida* C.B.P. 436 a. *Citrus medica* var. *Limon* L. Sp. 782. *Citrus Limon* Burm. (*C. Limonum* Risso).—Duhamel, *Traité des Arbres*, ed. 2, vii, t. 28 ; Risso et Poiteau, *Orangers*, ed. 2, tt. 70–95 ; B.T. 54 ; P.C. 162 ; R. 758 ; Dr. 359 ; H. 94.—*Limones* Tr. 1033, in obs.

329. *Punica malus*, 183 v., cum ic. ; Annot. Diosc. 22 v. *Malus punica sativa* C.B.P. 438 a ; J. 149. *Punica Granatum* L. Sp. 472 (cultivated plant).—Plenck, Ic. Pl. Med. iv, t. 376 ; Duhamel, *Traité des Arbres*, ed. 2, iv, tt. 11, 11 bis ; Hayne, *Arzn. Gewächse*, x, t. 35 ; B.T. 113 ; P.C. 224 ; L.P. 27 ; R. 942 ; Dr. 463 ; H. 148.—Tr. 1037 !

330. *Punica sylvestris*, 184 r., sine ic. *Malus punica sylvestris* C.B.P. 438 a. *Punica Granatum* L. Sp. 472 (wild plant).



331. *Ficus*, 184 r., ic. 184 v.; Annot. Diosc. 25 v. *Ficus communis* C.B.P. 457 a; J. 152. *Ficus Carica* L. Sp. 1059.—Duhamel, *Traité des Arbres*, ed. 2, iv, tt. 53–59; Plenck,  *Ic. Pl. Med.* viii, t. 736; Hayne, *Arzn. Gewächse*, ix, t. 13; B.T. 228; P.C. 104; R. 192; Dr. 172; H. 60.—F. 433; Tr. 1050!

332. *Caprificus*, 184 v., sine ic.; Annot. Diosc. 25 v. *Ficus sylvestris Dioscoridi* C.B.P. 457 b. *Ficus Carica* L. Sp. 1059 (*F. Caprificus* Risso).

333. *Olea*, 184 v., ic. 185 r.; Annot. Diosc. 21 r. *Olea sativa* C.B.P. 472 a; J. 155. *Olea europaea* L. Sp. 8.—Duhamel, *Traité des Arbres*, ed. 2, v, tt. 25–32; Hayne, *Arzn. Gewächse*, x, t. 10; B.T. 172; P.C. 201; R. 358; Dr. 525; H. 126.—Tr. 1061!

334. *Colymbades*, 185 r., sine ic.; Annot. Diosc. 21 r. *Olea europaea* L.—Olives pickled in brine.

335. *Oleum*, 185 v., sine ic. *Oleum commune* Annot. Diosc. 10 r. *Olea europaea* L.—Olive oil.

336. *Citrius altera*, 185 v., sine ic. *Poma Adami* Annot. Diosc. 24 r., cap. 167. *Malus Adami* C.B.P. 437 b. *Adami Pomum commune* Ferrari, *Hesperides*, 313. *Citrus Limetta* Risso var. *Pomum-Adami* Risso in *Ann. Mus. Par.* xx, 198 (1813).—Risso et Poiteau, *Orangers*, ed. 2, 92, t. 60; R. 759; Dr. 359.—*Adami poma* Matth. *Comm. Diosc.* 137, l. 13 (1554).

337. *Larix*, 185 v., ic. 186 r. *Larix* C.B.P. 493 a; C. 749; J. 161. *Larix folio deciduo* Hall. *Enum.* 149. *Pinus Larix* L. Sp. 1001. *Larix decidua* Mill. (*L. europaea* DC.).—Reichb. *Ic. Fl. Germ.* xi, t. 531; Köhler, *Med. Pl.* ii, t. 107; P.C. 159; R. 171; Dr. 69; H. 93.—F. 281; Tr. 1119!—vide no. 449.

338. *Oleaster Germanicus*, 186 r., cum ic.; Annot. Diosc. 21 r. *Rhamnus Salicis folio angusto fructu flavescente* C.B.P. 477 b; J. 157. *Rhamnoides* Hall. *Enum.* 161. *Hippophaë Rhamnoides* L. Sp. 1023.—Duhamel, *Traité des Arbres*, ed. 2, vi, t. 80; Guimpel, *Willd. u. Hayne, Abbild. deutsch. Holzart.* ii, t. 199; Reichb. *Ic. Fl. Germ.* xi, t. 549, fig. 1165; R. 243; Dr. 460.—*Rhamnus secundus* Matth. *Comm.* 97 (1554).

339. *Tamariscus foemina*, 186 v., ic. 187 r. *Tamariscus ampliore medulla* Annot. Diosc. 18 v. *Tamarix fruticosa folio crassiore: sive Germanica* C.B.P. 485 a; C. 748; J. 159. *Tamariscus floribus decandris* Hall. *Enum.* 419. *Tamarix germanica* L. Sp. 271. *Myricaria germanica* (L.) Desv.—*Regn. Bot.* iii, t. 154; Plenck, *Ic. Pl. Med.* iii, t. 241; Guimpel, *Willd. u. Hayne, Abbild. deutsch. Holzart.* i, t. 38; R. 752; Dr. 445.—F. 291; Tr. 955!

340 A. *Pseudocrania*, 187 r., excl. ic.; *Sylva*, 223 r. *Viburnum vulgo* C.B.P. 428; J. 148. *Lantana vulgo, aliis Viburnum* J. *Bauh. Hist.* i, pars 1, 557 b. *Viburnum foliis ovatis, crenatis, subtilus tomentosus* Hall. *Enum.* 467. *Viburnum Lantana* L. Sp. 268; Hoppe, *Ectypa Pl. Ratisbon.* t. 1.—Jacq. *Fl. Austr.* iv, t. 341; R. 353; Dr. 641.

The name *Pseudocrania* (Greek, 'false *Cornus*') implies a resemblance to *Cornus*. *Pseudocrania* is described by Cordus as a tree, 6–9 ft. high, with the stem very distorted (i.e. turned in different ways); leaves subrotund, sometimes ending in a point ('mucro') in shape intermediate between those of *Tilia*, *Betula*, and *Piraster* (*Pyrus communis*), and finely serrate; flowers produced after the beginning of spring on little shoots or branchlets ('e surculis ramulisque'); fruit a longish ('oblongam') berry (i.e. medium-sized fleshy fruit), turbinate at each end and resembling in shape the fruit of *Cornus* (*Cornus mas*). The habitat was among boulders on rocky hills above Regensburg.

These particulars point clearly to *Viburnum Lantana*, and exclude all other woody plants wild in Germany. The stem of this species exhibits a very characteristic forked branching, owing to the growth of the successive axes being terminated by the production of inflorescences. The shape of the fruit is also characteristic. *V. Lantana* is recorded from Regensburg by Hoppe (loc. cit.).

340 B. *Pseudocrania*, 187 r., quoad ic. tantum. *Cornus foemina* Annot. Diosc. 24 v. *Cornus foemina* C.B.P. 447 b; C. 745; J. 149. *Cornus umbellis involucro multo longioribus* Hall. Enum. 463. *Cornus sanguinea* L. Sp. 117.—Fl. Dan. III, t. 481; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. I, t. 3; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxvi, t. 2704; R. 570; Dr. 504.—Br. 257; Tr. 1004!

341. *Trifolia arbor*, 187 v., cum ic.; Sylva, 221 r., 223 r. *Anagyris non foetida major, vel Alpina* C.B.P. 391 a; C. 742; J. 142; S. 71. *Cytisus foliolis ovato oblongis, racemis simplicibus pendulis* Hall. Enum. 591, class. I. *Cytisus Laburnum* L. Sp. 739. *Laburnum anagyroides* Medikus (*L. vulgare* Griseb.).—Jacq. Fl. Austr. IV, t. 306; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. II, t. 127; L.P. 6; R. 987; Dr. 313; H. 229.

\*342. *Cytisus albus sylvestris*, 187 v., excl. ic. *Cytisus sulvestris* Sylva, 223 r. *Cytisus albicans, folio trifolii vulgaris* C.B.P. 390 a. *Cytisus supinus Sylvestris Ratisponensis, floribus luteis ad exortum foliorum prodeuntibus* Volkamer. Fl. Noriberg. 136 (1700). *Cytisus sylvestris Ratisbonensis* Weinm. Phyt. Ic. 320, t. 457, fig. b (1739). *Cytisus ratisbonensis* Schaeff. Botanica Expeditior, frontisp. (1760).—Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxiii, t. 2314; Bot. Mag. t. 8661; Hegi, Ill. Fl. IV, pars 3, t. 159, fig. 4; Dr. 313.

Referred by Dierbach (Beitr. Deutsch. Fl. I, 71: 1825) to *Cytisus supinus* L., but the description of the inflorescence given by Cordus indicates *C. ratisbonensis*:—"Flores post veris initium ab inferiore sui propemodum parte usque ad summitatum virgarum, e foliorum alis producit."

\*343. *Pseudocytisus, sive niger Cytisus*, 188 r. *Cytisus, qualis circa Scaphusiam in collibus nuper a nobis repertis est*, ic. 188 r. *Cytisus glaber nigricans* C.B.P. 390 b; C. 742; J. 142; S. 71. *Cytisus foliolis ovato oblongis, racemis simplicibus erectis* Hall. Enum. 591, class. I. *Cytisus nigricans* L. Sp. 739.—

Jacq. Fl. Austr. iv, t. 387; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. II, t. 129; Dietr. Fl. Boruss. ix, t. 642; Hegi, Ill. Fl. iv, pars 3, t. 159, fig. 5.

344 A. *Cornus foemina*, 188 r., excl. ic. 188 v.; Annot. Diosc. 24 v. *Telycrania* Sylv. 223 r. *Cornus foemina* C.B.P. 447 b; C. 745; J. 149. *Cornus sanguinea* L. Sp. 117.—vide no. 340 B.

Described as differing from *Cornus mascula* (*Cornus mas*) in the stem being lower and not so straight, the flowers smaller, greenish white, appearing later, the more astringent berries, and the less dense wood. The involucrate umbel of *Cornus mas* was evidently regarded by Cordus as a single 'flower'.

344 B. *Cornus*, 188 v., quoad adnot. et ic. tantum. *Cornus sativa sive mas*, Annot. Diosc. 24 v. *Cornus hortensis mas* C.B.P. 447 a; C. 745; J. 149. *Cornus mas* Hall. Enum. 463. *Cornus mas* L. Sp. 117.—Plenck, Ic. Pl. Med. I, t. 64; Oskamp, Afbeeld. Artseny-Gewass. II, t. 149; Duhamel, Traité des Arbres, ed. 2, II, t. 43; Sibth. Fl. Graec. II, t. 157; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. I, t. 2; L.P. 87; R. 569; Dr. 504.—Tr. 1024!

345. *Cotonea malus sylvestris*, 188 v., sine ic. *Cydonia sive Cotonea, tertium genus* Annot. Diosc. 23 v., cap. 160, 161. *Malus cotonea sylvestris* C.B.P. 435 a. *Pyrus Cydonia* L. Sp. 480. *Cydonia oblonga* Mill. (naturalized plant).—vide no. 325.

Naturalized on both banks of the Danube, above Regensburg, and above Kelheim.

346 A. *Thymelaea minor*, 188 v., excl. ic. 187 r.; Sylva, 221 v. *Thymelaeae affinis facie externa* C.B.P. 463 a; J. 153. *Thymelaea floribus ex summis ramis eminentibus, folio levi, perangusto* Hall. Enum. 187. *Daphne Cneorum* L. Sp. 357; Vollmann, Fl. Bayern, 535.—Jacq. Fl. Austr. v, t. 426; Duhamel, Traité des Arbres, ed. 2, I, t. 10; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. I, t. 50; Reichb. Ic. Fl. Germ. XI, t. 554, fig. 1176; R. 241; Dr. 459.

\*346 B. *Thymelaea minor*, 189 r., quoad ic. tantum. *Thymelaea minor, vel Daphnoides alpinum* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. i, 5, t. 3, fig. 6, A, B (1759). *Daphne striata* Tratt. Arch. Gewächsk. II, 120, t. 133 (1814).—Reichb. Ic. Fl. Germ. XI, t. 554, fig. 1177; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, x, t. 981.

Gesner, like Wahlenberg at a later date (Veg. Clim. Helv. Sept. 72: 1813), confused *D. striata* with *D. Cneorum*. The branching of the stem is very different in the two species.

347 A. *Genista angulosa*, 189 r., excl. ic. 189 v. *Genista* Annot. Diosc. 74 r. *Genista angulosa et scoparia* C.B.P. 395 a; C. 743; J. 143; S. 72. *Spartium scoparium* L. Sp. 709. *Cytisus scoparius* (L.) Link. *Sarothamnus scoparius* (L.) Koch.—Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. II, t. 116; B.T. 70; P.C. 38; L.P. 284; R. 985; Dr. 313.—Br. 197; F. 123; Tr. 961 (*Genista*).

347 B. *Genista angulosa*, 189 v., quoad ic. tantum. *Chamaegenista sagittalis* C.B.P. 395 b; C. 743; J. 144; S. 72. *Genista foliorum parte prima cauli adnata, elliptica, altera patente lanceolata* Hall. Enum. 593. *Genista sagittalis* L. Sp. 710.—Jacq. Fl. Austr. III, t. 209; Guimpel, Willd. u. Hayne, Abbild. deutsch. Holzart. II, t. 117; R. 986; Dr. 311.—Tr. 602!

348. *Genista iuncea*, 189 v., ic. 190 r. *Genista quaedam sive Spartum* Annot. Diosc. 74 r. *Genista iunceis virgis, visque non angulosis, sed teretibus* Sylva, 221 r. *Spartium arborescens seminibus lenti similibus* C.B.P. 396 a; C. 743; J. 144; S. 72. *Spartium junceum* L. Sp. 708.—Regn. Bot. III, t. 125; Sibth. Fl. Graec. VII, t. 671; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XXIII, t. 2293; R. 984; Dr. 312; H. 17.—F. 434.

Described from a plant cultivated in the garden of D. D. Schaller at Nürnberg.

\*349. *Lycostaphylus mascula*, 190 r., sine ic. Sylva, 223 r. *Sambucus aquatica flore globoso pleno* C.B.P. 456 b; C. 747; J. 152. *Sambucus rosea* J. Bauh. Hist. I, pars 1, 553 b. *Opulus* Hall. Enum. 463, var.  $\beta$ . *Viburnum Opulus* var. *roseum* L. Sp. 268 (*V. Opulus* var. *sterile* DC.).—Nichols. Diet. Gard., Cent. Suppl. II, 735, fig. 761; Hegi, III. Fl. VI, pars 1, 245, fig. 135; R. 354; Dr. 641.

350. *Anagyris*, 190 v., cum ic.; Annot. Diosc. 60 v., adnot. *Anagyris foetida* C.B.P. 391 a; J. 142; S. 71. *Anagyris foetida* L. Sp. 374.—Duhamel, Traité des Arbres, ed. 2, v. t. 42; Chaumeton, Fl. Med. I, t. 22; Sibth. Fl. Graec. IV, t. 366; Reichb. Ic. Fl. Germ. XXII, t. 5; Bonnier, Fl. Compl. II, t. 116, fig. 603; R. 981; Dr. 310.—Tr. 619!

*Liber IV : In quo lignorum, corticum, et fructuum peregrinorum : item  
peregrinarum radicum et lachrymarum descriptiones habentur.*

351 A. *Guaiacum*, 191 r., excl. ic. *Guaiacum officinale* L. Sp. 381; Urb. Symb. Antill. VIII, 317; Fawc. and Rendle, Fl. Jam. IV, 163, fig. 52; Record, Timbers Trop. Am. 315.—Nees, Pl. Offic. II, t. 380; Hayne, Arzn. Gewächse, XII, t. 28; Köhler, Med. Pfl. I, t. 88; B.T. 41; P.C. 124; R. 886; Dr. 344; F.H. 100, 103; Tsch. II, 1535; H. 68, 96.

The most prized kind of *Guaiacum*, described by Cordus, was *G. officinale*. The wood of *G. sanctum* L. was less esteemed.

351 B. *Guaiacum*, 191 r., quoad ic. tantum. *Lotus Africana latifolia* C.B.P. 447 a; J. 149. *Guaiacana* J. Bauh. Hist. I, pars 1, 237. *Diospyros Lotus* L. Sp. 1057; Hiern, Monogr. Ebenac. in Trans. Camb. Phil. Soc. XII, pars 1, 223.—Duhamel, Traité des Arbres, ed. 2, VI, t. 26; Reichb. Ic. Fl. Germ. XVII, t. 1079; R. 512; Dr. 521; H. 48.

\*352. *Presilium lignum*, 191 v., sine ic. *Pseudosantalum rubrum sive arbor Brasilia* C.B.P. 393 a. *Caesalpinia echinata* Lam. Encycl. I, 461; Benth. in, Mart. Fl. Bras. XV, pars 2, 66, t. 22; Holland in Kew Bull. 1916, 212; Record,

Timb. Trop. Am. 248; Wiesner, Rohstoffe, ed. 4, II, 1422.—Chaumeton, Fl. Med. II, t. 72; Zenker u. Schenk, Merkant. Waarenk. III, t. 51; R. 1033; Dr. 306; Tsch. III, 921; H. 141.

\*353. *Presilium citrinum*, 191 v., sine ic. *Morus tinctoria* L. Sp. 986. *Broussonetia tinctoria* (L.) H. B. K. *Maclura tinctoria* (L.) D. Don. *Chlorophora tinctoria* (L.) Gaudich.; Record, Timb. Trop. Am. 120; Pittier, Man. Pl. Us. Venez. 324; Wiesner, Rohstoffe, ed. 4, II, 1374.—Descourtilz, Fl. Antilles, VI, t. 431; Mart. Fl. Bras. IV, pars 1, 155, t. 51; Archer, Profitable Plants, t. 15, fig. 77; R. 192; Dr. 172; Tsch. III, 933; H. 62, 132.

The wood of *Chlorophora tinctoria* (Fustic) has been known under the names 'lignum citrinum', 'bois de Brésil jaune', and 'gelbes brasil holz' (Gerth van Wijk, Dict. Pl. Names, I, 300). It yields a yellow dye. The tree has a very wide distribution in tropical America. These facts suggest that *Presilium citrinum* Cord., which was used for dyeing wool and cloth yellow, was *Chlorophora tinctoria*, which is one of the most important dye-woods of commerce. Record (loc. cit.) states that its use dates back to the middle of the seventeenth century. If our identification is correct, it was used during the first half of the sixteenth century.

354. *Sandalum rubeum*, 191 v., sine ic. *Santalum rubrum* C.B.P. 393 a; J. 143. *Sandalum rubrum* Rumph. Herb. Amboin. II, 47 (1750). *Pterocarpus santalinus* L. f. Suppl. 319 (1781); Wiesner, Rohstoffe, ed. 4, II, 1428.—Woodville, Med. Bot., Suppl. t. 254; Köhler, Med. Pfl. II, t. 153; B.T. 82; P.C. 249; R. 1024; Dr. 327; F.H. 199; Tsch. III, 924; B.P.C. 858; H. 175.

355. *Sandalum citrinum*, 191 v., sine ic. *Santalum pallidum* C.B.P. 392 a; J. 143. *Santalum citrinum* Dale, Pharmacol. ed. 3, 325 a (1737). *Sandalum pallidum seu Citrinum* Rumph. Herb. Amboin. II, 44, 47, t. 11 (1750). *Santalum album* L. Sp. 349 (heart wood); Wiesner, Rohstoffe, ed. 4, II, 1383.—Woodville, Med. Bot., Suppl. t. 264; Hayne, Arzn. Gewächse, x, t. 1; Köhler, Med. Pfl. III, t. 271; B.T. 252; P.C. 245; R. 238; Dr. 183; F.H. 599; Tsch. II, 950; B.P.C. 739; H. 174.

356. *Sandalum album*, 191 v., sine ic. *Santalum album* C.B.P. 392 a; J. 143. *Santalum album* L. Sp. 349 (sap wood).

357. *Agalochum*, id est, *Xyloaloe solida et ponderosa*, 191 v., sine ic. *Agallochum* Annot. Diosc. 7 v. *Aspalathus albicans torulo citreo* C.B.P. 392 a. *Aquilaria Agallocha* Roxb. Fl. Ind. ed. 2, II, 422; Dymock, Veg. Mat. Med. W. India, ed. 2, 674; Dymock, Warden and Hooper, Pharmacogr. Ind. 217; Gamble, Man. Indian Timbers, 579; Watt, Dict. Econ. Prod. India, I, 279; Hooper in Gardens Bull. Straits Settlm. VI, 13; Metcalfe in Kew Bull. 1933, 4; Burkill, Dict. Econ. Prod. Mal. Penins. I, 198; H. 54.—*Linaloes* Garcia da Orta, Colloquies, transl. Markham, 251.—Hook. Ic. Pl. I, t. 6; Royle, Illustr. t. 36, fig. 1; R. 243; Dr. 458,

Eagle Wood or Lign Aloes, a drug of great antiquity, valued as a medicine and perfume. It consists of portions of diseased wood of *Aquilaria Agallocha* which have become infiltrated with a fragrant resin. *Agalochum* (*Xylaloe solida et ponderosa*) Cord. was the best kind, which is black, hard, and heavy, sinking in water. *Tarum* (*Xylaloe fissilis, levis, et aromatica*) Cord. and *Tarum crispum* Cord. were inferior and lighter kinds.

358. *Tarum, id est, Xyloaloe fissilis, levis, et aromatica*, 192 r., sine ic. *Agallochum officinarum* C.B.P. 393 b. *Aquilaria Agallocha* Roxb.—vide no. 357.

359. *Tarum crispum*, 192 r., sine ic. *Agallochum officinarum* C.B.P. 393 b. *Aquilaria Agallocha* Roxb.—vide no. 357.

360. *Cinnamomum characium*, 192 r., sine ic. *Cinnamomum* Annot. Diosc. 3 v. *Cinnamomum sive Canella Zeilanica* C.B.P. 408 a; J. 145. *Laurus Cinnamomum* L. Sp. 369. *Cinnamomum zeylanicum* Blume, Bijdr. xi, 568 (1825).—Hayne, Arzn. Gewächse, xii, t. 20; Köhler, Med. Pfl. i, t. 48; B.T. 224; P.C. 70; R. 229; Dr. 238; F.H. 519; Tsch. ii, 1273; B.P.C. 331; H. 33.

361. *Casia aromatica*, 192 r., sine ic. *Casia* Annot. Diosc. 3 r. (1) *Cinnamomum Cassia* Nees ex Blume, Bijdr. xi, 570 (1825), bark; Dyer in Journ. Linn. Soc. Lond., Bot. xx, 19; Burkill, Dict. Econ. Prod. Mal. Penins. i, 548.—Hayne, Arzn. Gewächse, xii, t. 23; Köhler, Med. Pfl. i, t. 47; B.T. 223; P.C. 59; Dr. 239; Tsch. ii, 1261; B.P.C. 294; H. 25. (2) *Cinnamomum Tamala* (Ham.) T. Nees et Eberm. and possibly other species; T. Nees et Eberm. Handb. Med.-Pharm. Bot. ii, 427, iii, 525; Watt, Commenc. Prod. India, 311, 313; Gerth Van Wijk, Dict. i, 318.—vide no. 402.

362. *Xylobalsamum*, 192 v., sine ic. *Balsamum* Annot. Diosc. 9 r. *Xylobalsamum officinarum* C.B.P. 401 a. *Amyris Opobalsamum* L. Diss. Opobals. 14 (1764); Mant. 65 (1767); Amoen. Acad. vii, 69 (1769); Mat. Med. 101 (1773). *Amyris gileadensis* L. *Balsamodendron Opobalsamum* (L.) Kunth. *Commiphora Opobalsamum* (L.) Engl.—Balessan, Bruce, Trav. v, 16, tt. 2, 3; B.T. 59; R. 861, 862; Dr. 368; Tsch. i, 532; H. 10.—vide nos. 388, 434.

363. *Narcaphthum, vel Thymiaema et Storax rubea*, 192 v., sine ic.; Annot. Diosc. 8 v. *Styrax sicca seu Thymiaema* Annot. Diosc. 14 v., cap. 81. *Storax rubra officinarum* C.B.P. 452 a, 502 b. *Liquidambar orientalis* Mill.—Hook. Ic. Pl. t. 1019; Hanbury in Pharm. Journ. xvi, 461–465 (1857); Köhler, Med. Pfl. ii, t. 112; B.T. 107; P.C. 271; R. 203; Dr. 270; F.H. 271; Tsch. iii, 1048, 1059; B.P.C. 1022; H. 196.—vide nos. 370 C, 442.

According to Hanbury (loc. cit.) the residual bark of *L. orientalis*, after extraction of the Liquid Storax, is known to pharmacologists as Cortex Thymiamatis, Narcaphthum, and Red Storax.

364. *Nux Indica grandis*, 192 v. *Nux Indica*, ic. 193 r. *Palma Indica coccifera angulosa* C.B.P. 508 b. *Cocos nucifera* L. Sp. 1188; Burkill, Dict.

Econ. Prod. Mal. Penins. I, 598.—Köhler, Med. Pfl. III, t. 233, 234; R. 161; Dr. 100; B.P.C. 700; H. 35, 38.

365. *Nux Indica minor, vel Cuci*, 193 r., sine ic.—Not identified. The description seems inconsistent with *κουκιοφόρον* Theophr., *Cuci* Plin., which is *Hyphaene thebaica* (L.) Mart. Hist. Nat. Palm. III, 225, tt. 131–33.

366. *Nux moschata mascula vel maior*, 193 r., sine ic. *Nux moschata fructu oblongo* C.B.P. 407 b. *Myristica* sp.—The seeds of a species of *Myristica*, probably *M. malabarica* Lam., the fruits of which have long been used for the purpose of adulterating the nutmegs and mace of *M. fragrans* Houtt. Cordus stated that the seeds resembled dates in shape and size, and that they were imported with other spices sometimes mixed with the true nutmeg.—Beddome, Fl. Sylv. t. 269.

367. *Nux moschata*, 193 v., sine ic. *Nuces Muschatae* Annot. Diosc. 18 r. sub *Macer*. *Nux moschata fructu rotundo* C.B.P. 407 a; J. 145. *Myristica fragrans* Houtt. (nutmeg).—Köhler, Med. Pfl. II, t. 125; B.T. 218; P.C. 198; R. 586; Dr. 218; F.H. 502; Tsch. II, 665; B.P.C. 661; H. 120.

368. *Macis seu Macer*, 193 v., sine ic.; Annot. Diosc. 18 r. *Myristica fragrans* Houtt. (mace).—P.C. 174.—vide no. 367.

369. *Faufel, vel avellana Indica*, 193 v., sine ic. *Palma cujus fructus sessilis Faufel dicitur* C.B.P. 510 a. *Areca Catechu* L. Sp. 1189; Burkill, Dict. Econ. Prod. Mal. Penins. I, 223.—Köhler, Med. Pfl. I, t. 17; B.T. 276; P.C. 13; R. 148; Dr. 96; F.H. 669; Tsch. III, 222; B.P.C. 150.

370 A. *Nux Styracina*, 194 r., cum ic. et fig. A. *Styrax* Annot. Diosc. 14 r. *Styrax folio mali cotonei* C.B.P. 452 a; J. 150. *Styrax (sive Storax officinarum)* C.B.P. 502 a. *Styrax officinalis* L. Sp. 444.—Woodville, Med. Bot. II, t. 71; Sibth. et Sm. Fl. Graec. IV, t. 375; Hayne, Arzn. Gewächse, XI, t. 23; R. 512; Dr. 522; F.H. 276; Tsch. III, 1050, 1057.—*Styrax* Matth. Comm. 63, cum ic. (1554).—vide nos. 441, 442.

370 B. *Granum quoddam ruffum, quod apud pharmacopolas cum Styraee calamite invenitur*, 194 r., fig. B.—Not identified.

370 C. *Fructus quidam cum Styraee rubea apud pharmacopolas*, 194 r., fig. C. *Liquidambar orientalis* Mill.—vide nos. 363, 442.

The figure represents an infructescence of *Liquidambar orientalis* and thus confirms the identification of *Storax rubea* (no. 363), since it was found with that bark in the druggists' shops.

371. *Nux vomica*, 194 r., sine ic. *Nux vomica in Officinis* C.B.P. 511 a; J. 161. *Strychnos Nux-vomica* L. Sp. 189.—Hayne, Arzn. Gewächse, I, t. 17; Köhler, Med. Pfl. II, t. 177; B.T. 178; P.C. 199; R. 361; Dr. 533; F.H. 429; Tsch. III, 448; B.P.C. 674; H. 120.

372. *Anacardium*, 194 v., sine ic. *Anacardium officinarum* Garcia ab Horto, Arom. et Simpl. Medic. Hist. ed. Clusius, 140 (1567). *Anacardium* C.B.P. 511 b; J. 161. *Anacardium orientale* Lochner, Rar. Mus. Besl. 16 (1716). *Anacardium* Lochner, op. cit. t. 4. *Anacardium* Dale, Pharmacol. ed. 3, 310 (1737). *Anacardium officinarum* Gaertn. Fruct. i, 192, t. 40, fig. 1 (1788). *Semecarpus Anacardium* L. f. Suppl. 182 (1781); Roxb. Pl. Coromandel, i, 13, t. 12; Burkill, Dict. Econ. Prod. Mal. Penins. II, 1991.—Hayne, Arzn. Gewächse, i, t. 1; R. 856; Dr. 394; Tsch. III, 879.

Described by Cordus as a black shining fruit, shaped like a bird's heart, and at most an inch long, with a flat white kernel enclosed in a shell full of cavities like tuff or pumice-stone, containing a viscous blackish liquid with very astringent properties. These details point unmistakably to *Semecarpus Anacardium*, the shape of the fruit excluding *Anacardium occidentale* L.

373. *Balanus Myrepsica*, 194 v., sine ic.; Annot. Diosc. 11 r. *Glans unguentaria* C.B.P. 402 a. *Guilandina Moringa* L. Sp. 381. *Moringa oleifera* Lam. Encycl. i, 398 (1785) (*M. pterygosperma* Gaertn., 1791); Burkill, Dict. Econ. Prod. Mal. Penins. II, 1495.—Gaertn. Fruct. II, 314, t. 147; Wight, Ill. i, t. 77; R. 1048; Dr. 263; H. 79.

The description of the seed as triquetrous ('fructus . . . figura triquetrus') indicates *M. oleifera*.

374. *Siliqua Indica, seu Cassia fistula*, 194 v., sine ic. *Cassia fistula Arabum* Annot. Diosc. 3 r. *Cassia fistula Alexandrina* C.B.P. 403 a. *Cassia fistula* L. Sp. 377; Burkill, Dict. Econ. Prod. Mal. Penins. I, 475.—Hayne, Arzn. Gewächse, IX, t. 39; B.T. 87; R. 1035; Dr. 301; B.P.C. 295.

375. *Carpesium*, 195 r., sine ic. *Piper aethiopicum* Matth. Epit. ed. Calceol. 346 (1586). *Piper oblongum nigrum* C.B.P. 412 a. *Unona aethiopica* Dunal, Monogr. Anonac. 113 (1817). *Xylopi aethiopica* (Dunal) A. Rich.; Engl. Mon. Afr. Pfl.-Fam. VI, 60; Rochebrune, Toxicol. Afr. i, 398–420, fig. 156; Index Minor Forest Prod. Brit. Empire, 23 (1936); Dalziel, Useful Pl. W. Trop. Afr. 8.—Baill. Hist. Pl. i, 223, fig. 261; R. 590; Dr. 217; H. 140.

Erroneously stated by Cordus to be the fruit of an Asiatic tree, whereas *Xylopi aethiopica* is a native of West Africa.

376. *Amomum*, 195 r., sine ic.; Annot. Diosc. 3 v. *Rosa Hierichuntica* Cam. Hort. Med. 147, et Ic. t. 41 (1588). *Rosa Hierochuntea vulgo dicta* C.B.P. 484 b; C. 748; J. 159. *Anastatica hierochuntica* L. Sp. 641.—Bot. Mag. t. 4400; R. 635; Dr. 260; H. 165.—*Amomum seu Hierichuntis rosa* Eur. Cord. Botanolog. 19 (1534).

*Amomon* Diosc. (Mat. Med., ed. Spreng. i, 28) was apparently *Dionysia diapensiifolia* Boiss. (Primulaceae).—vide *Amomum* Garcia ab Horto, Arom. Hist. 124 (1593); Holmes in Pharm. Journ. ser. 3, XVIII, 155 (1887); Dymock, Warden and Hooper, Pharmacogr. Ind. II, 340.



377. *Melligetta*, *id est*, *grana Paradisi*, seu *cardamomum piperatum*, 195 v., sine ic. *Melegueta sive Grana Paradisi* C. Bauh. Prodr. 158 a (1620). *Grana paradysi officinarum* C.B.P. 413 a. *Amomum Melegueta* Roscoe, Monandr. Pl. t. 98 (1828). *Aframomum Melegueta* (Roscoe) K. Schum. in Engl. Pflanzenreich, iv. 46 (Zingiberac.), 204.—Pharm. Journ. ser. 4, xiii, 251; B.T. 268; R. 131; Dr. 145; F.H. 651; Tsch. II, 1088; B.P.C. 767; Dalziel, Useful Pl. W. Trop. Afr. 471; H. 140.

\*378. *Cardamomum maius*, 195 v., sine ic.; Annot. Diosc. 1 v., 2 r. *Cardamomum majus officinarum* C.B.P. 413 b. *Amomum Korarima* Pereira, Mat. Med. ed. 2, 1136, fig. 245–247 (1842); and ed. 3 (1850); K. Schum. in Engl. Bot. Jahrb. xv, 418 (1892); Kew Bull. 1894, 400; Kew Guide Mus. Econ. Bot. no. 2, 9 (1895); Mahon in Kew Bull. 1898, 288; K. Schum. in Engl. Pflanzenr. iv. 46 (Zingiberac.), 221 (ut *Aframomum* sp.).—Horaninow, Scitam. t. 4, fig. 4, a, b; R. 1086; F.H. 650; Tsch. II, 1088; H. 23.

\*379. *Cardamomum mediocre*, 195 v., sine ic. *Cardamomum medium* C.B.P. 414 a. *Elettaria major* Sm. in Rees, Cyclop. xxxix, Addenda; K. Schum. in Engl. Pflanzenr. iv. 46 (Zingiberac.), 269. *Elettaria Cardamomum* Maton var. *major* Thw.; Burkill, Dict. Econ. Prod. Mal. Penins. I, 914.—Pereira, Mat. Med. ed. 3, II, 1145, figs. 264, 265; R. 132; F.H. 644; Tsch. II, 1085; B.P.C. 285.

The wild, large-fruited Cardamom of Ceylon. Garcia da Orta (1563) mentions the existence in Ceylon of a Cardamom which had larger and less aromatic fruits than the common one of his day ('Colloquies on the Simples and Drugs of India,' ed. Markham, 107: 1913).

380. *Cardamomum minus*, 195 v., sine ic.; Annot. Diosc. 1 v., 2 r. *Cardamomum simpliciter in officinis dicta* C.B.P. 414 b; J. 145. *Alpinia Cardamomum* Roxb. in Asiat. Researches, XI, 355 (1810). *Elettaria Cardamomum* Maton in Trans. Linn. Soc. Lond. x, 254 (1811); Sm. in Rees Cyclop. xxxix, Addenda; K. Schum. in Engl. Pflanzenr. iv, 46 (Zingiberac.), 268. *Elettaria Cardamomum* var. *minuscula* Burkill in Kew Bull. 1930, 35; Burkill, Dict. Econ. Prod. Mal. Penins. I, 910.—Pereira, Mat. Med. ed. 3, II, 1142, fig. 261–3; B.T. 267; R. 131; F.H. 643; Tsch. II, 1072; B.P.C. 284; H. 23.

The Malabar Cardamom.

381. *Caryophyllus immaturus* aut *minor*, 196 r., sine ic. *Caryophyllus aromaticus fructu oblongo* C.B.P. 410 a; J. 145. *Caryophyllus aromaticus* L. Sp. 515. *Eugenia aromatica* (L.) Baill. (1877), non Berg (1854–5). *Eugenia caryophyllata* Thunb. (Cloves).—Hayne, Arzn. Gewächse, x, t. 38; B.T. 112; P.C. 72; R. 925; Dr. 472; F.H. 280; Tsch. II, 1223; B.P.C. 288; H. 34.—vide nos. 382, 383, 403.

382. *Caryophyllus maturus* seu *maior*, 196 r., sine ic. *Eugenia caryophyllata* Thunb. (Mother Cloves).—vide prae.

383. *Festuca Caryophyllorum*, 196 r., sine ic. *Eugenia caryophyllata* Thunb. (Clove Stalks).—vide no. 381.

384. *Piper longum*, 196 r., sine ic.; Annot. Diosc. 46 v. *Piper longum orientale* C.B.P. 412 a; J. 145. *Piper longum* L. Sp. 29 (*Chavica Roxburghii* Miq.); Burkill, Dict. Econ. Prod. Mal. Penins. II, 1744 (Indian Long Pepper).—Hayne, Arzn. Gewächse, XIV, t. 20; B.T. 244; R. 178; Dr. 156; F.H. 582; Tsch. III, 194.

385. *Piper album atque nigrum*, 196 v., sine ic.; Annot. Diosc. 46 v. *Piper rotundum nigrum* C.B.P. 411 a; J. 145. *Piper rotundum album* C.B.P. 412 a; J. 145. *Piper nigrum* L. Sp. 28; Burkill, Econ. Prod. Mal. Penins. II, 1746 (Black Pepper, White Pepper).—Hayne, Arzn. Gewächse, XIV, t. 6; B.T. 245; P.C. 212; R. 176; Dr. 154; F.H. 576; Tsch. III, 168; B.P.C. 810; H. 139.

386. *Bresma sive Brasma*, 196 v., sine ic. *Piper abortivum* C.B.P. 412 b.—Probably the 'Garble' or refuse of *P. nigrum* (no. 385). According to Cordus, the German merchants called it 'Gerbelier', and it was similar to Black Pepper, but lighter and less potent ('imbecillius').

387. *Cubebae*, 196 v., sine ic. *Cubebae vulgares nec Arabum Cubebae, nec Galeni Carpesium* C.B.P. 412 a; J. 145. *Piper Cubeba* L. f. Suppl. 90 (1781) (*Cubeba officinalis* Miq.); Burkill, Dict. Econ. Prod. Mal. Penins. II, 1743.—Hayne, Arzn. Gewächse, XIV, t. 8; B.T. 243 (excl. ic. plantae cultae); P.C. 88; R. 178; Dr. 157; F.H. 584; Tsch. III, 182; B.P.C. 373; H. 43, 139.

388. *Carpobalsamum*, 197 r., sine ic. *Balsamum* Annot. Diosc. 5 r. *Balsamum Syriacum rutae folio* C.B.P. 400 a. *Amyris Opobalsamum* L. Diss. Opobals. 14 (1764); Mant. 65 (1767); Amoen. Acad. VII, 69 (1769); Mat. Med. ed. 2, 101 (1773). *Amyris gileadensis* L. *Balsamodendron Opobalsamum* (L.) Kunth. *Commiphora Opobalsamum* (L.) Engl. (fruit).—Balessan, Bruce, Trav. v, 16, tt. 2, 3; B.T. 59; R. 861, 862; Dr. 368.—vide nos. 362, 434.

389. *Cuculi fructus*, 197 r., sine ic. *Solanum furiosum* Annot. Diosc. 67 r. *Cocculae officinarum* C.B.P. 511 b; J. 161. *Menispermum foliis cordatis retusis mucronatis* L. Mat. Med. 58, no. 175 (1749). *Menispermum Cocculus* L. Sp. 340; Mat. Med. ed. 2, 216, no. 504 (1773). *Anamirta paniculata* Colebr. *Anamirta Cocculus* (L.) Wight et Arn.; Diels in Engl. Pflanzenr. IV, 94 (Menispermac.), 108.—Nees, Pl. Offic. tt. 365, 366; B.T. 14; P.C. 74; R. 583; Dr. 235; F.H. 31; Tsch. III, 817; B.P.C. 339; H. 34.

390. *Tamarindus*, 197 r., sine ic. *Siliqua Arabica, quae Tamarindus* C.B.P. 403 a. *Tamarindus indica* L. Sp. 34; Burkill, Dict. Econ. Prod. Mal. Penins. II, 2121.—Hayne, Arzn. Gewächse, X, t. 41; B.T. 92; P.C. 278; R. 1035; Dr. 299; F.H. 224; Tsch. II, 528; B.P.C. 1038; H. 205.

391. *Myrobalanus Inda*, 197 v., sine ic. *Myrobalani nigrae octangulares* C.B.P. 445 b; J. 149. *Terminalia Chebula* Retz. Obs. v, 31 (1789) (unripe

dried fruits); Fleming in *Asiat. Researches*, xi, 181 (1810); Dymock, Warden and Hooper, *Pharmacogr. Ind.* ii, 1; Watt, *Dict. Econ. Prod. India*, vi, pt. 4, 24, 33; *Commerc. Prod. India*, 1073; *Bull. Imp. Inst.* xxvi, 23; Burkill, *Dict. Econ. Prod. Mal. Penins.* ii, 2139.—Roxb. *Pl. Corom.* ii, t. 197; Bedd. *Fl. Sylv.* t. 27; *Pharm. Journ. ser.* 4, xiii, 521; R. 901; Dr. 479; B.P.C. 662; H. 117.

The fruits of *Terminalia citrina* Roxb. may have been included also under nos. 391–3.—vide Gamble, *Man. Indian Timbers*, ed. 2, 340 (1902).

392. *Myrobalanus citrina*, 197 v., sine ic. *Myrobalani teretes citrini bilem purgantes* C.B.P. 445 a; J. 149. *Terminalia Chebula* Retz. (half-ripe fruits).—vide præc.

393. *Chaebula*, 197 v., sine ic. *Myrobalani mazimi oblongi angulosi pituitum purgantes* C.B.P. 445 a; J. 149. *Terminalia Chebula* Retz. (ripe fruits).—vide no. 391.

394. *Myrobalanus Belliricus*, 198 r., sine ic. *Myrobalani rotundae belliricae* C.B.P. 445 a; J. 149. *Myrobalanus Bellerica* Breyn.  *Ic. Rar. Pl.* 18, t. 4 (1739). *Myrobalanus Bellirica* Gaertn. *Fruct.* ii, 90, t. 97, fig. 2 (1791). *Terminalia Bellerica* Roxb. *Pl. Corom.* ii, 54, t. 198 (1798); Watt, *Dict. Econ. Prod. India*, vi, pt. 4, 18; *Commerc. Prod. India*, 1072; Burkill, *Dict. Econ. Prod. Mal. Penins.* ii, 2136.—Wight, *Ill. Ind. Bot.* i, t. 91; R. 901; Dr. 479.

395. *Myrobalanus Emblicus*, 198 r., sine ic. *Myrobalani Emblicae* C.B.P. 445 b; J. 149. *Phyllanthus Emblica* L. *Sp.* 982; Watt, *Dict. Econ. Prod. India*, vi, pt. 1, 217; *Commerc. Prod. India*, 886. *Emblica officinalis* Gaertn.; Burkill, *Dict. Econ. Prod. Mal. Penins.* i, 920.—Plenck, *Ic. Pl. Med.* vii, t. 659; Gaertn. *Fruct.* ii, t. 108; R. 840; Dr. 374.

396 A. *Pistaciae*, 198 r., excl. ic. 198 v.; Annot. Diosc. 25 r. *Pistacia peregrina fructu racemoso, sive Terebinthus Indica, Theoph.* C.B.P. 401 a; J. 144; S. 72. *Pistacia vera* L. *Sp.* 1025; Watt, *Dict. Econ. Prod. India*, vi, pt. 1, 273; *Commerc. Prod. India*, 902.—Duhamel, *Traité des Arbres*, ed. 2, iv, t. 17; Hayne, *Arzn. Gewächse*, xiii, t. 18; R. 845; Dr. 395; H. 145.

396 B. *Pistaciae*, 198 v., ic. tantum. *Semences de Terebinthes* Belon, *Obs.* 154, livre ii, chap. xvi (1553). *Kleine frembde Terebinthennüzlein* Rauwolf, *Raisz*, 228, 245 (1583). *Ein anderer Indianischer Terebinthenbaum* Rauwolf, *Raisz*, Vierte Theil, ic. fol. F v. (1583). *Semina Terebinthi* Belon, *Plur. Sing. Mem. Rer.* ed. Clusius, 363, lib. ii, cap. xvi (1589). *Terebinthus peregrina fructu minore et caeruleo, eduli* C.B.P. 400 b; Gronov. *Fl. Or.* 129, no. 314 (1755). *Terebinthus Indica fructu parvo, ad Corculum accedente* J. Bauh. *Hist.* i, pars 1, 279 a (1650). *Pistacia narbonensis* var. *Bauhini* Ten. *Ind. Sem. Hort. Neap.* 1854 [p. 4]; *Ann. Sc. Nat. sér.* 4, i, 328 (1854). *Pistacia cappadocica* [Tournef. ex] Planch. in *Bull. Soc. Bot. France*, xi, p. xlvii (1864). *Pistacia Terebinthus* × *vera* Engl. in *DC. Monogr.* iv, 292 (1883).

Possibly a hybrid, *Pistacia vera* ♀ × *Terebinthus* ♂: 'Est-ce un hybride entre les Pistachiers cultivés et le Térébinthe dont le pollen est si naturellement transporté sur les fleurs femelles des Pistachiers à gros fruit? Cette dernière idée, émise par Gasparini, est vraisemblablement la plus juste.'—Planchon, loc. cit. p. xlvii.

397. *Amygdalae minores*, 198 v., sine ic. *Amygdalus* spp.

Resembling the common almond, but only one-third or one-quarter the size. Both bitter and sweet kinds were imported in their shells with Asiatic galls and other drugs from Asia. Possibly these small almonds may have been the produce of one or more of the following wild species of the Near East which are stated to have edible fruits: *Amygdalus nana* L., *A. campestris* Bess., *A. agrestis* Boiss., *A. orientalis* Mill., *A. arabica* Olivier, *A. scoparia* Spach.—vide Rosenthal, Syn. Pl. Diaph. 971.

398. *Persica minora*, 198 v., sine ic. *Persica aestiva Armeniacis similia*, sive *Persica S. Johannis* C.B.P. 440 b. *Amygdalus Persica* L. Sp. 472 (*Prunus Persica* Sieb. et Zucc.), small-stoned form.—Hayne, Arzn. Gewächse, iv, t. 38; Reichb. Ic. Fl. Germ. xxv, t. 86; R. 972; Dr. 284.

399. *Juiubae seu Zizypha*, 198 v., ic. 199 r. *Jujubae majores oblongae* C.B.P. 446 a; J. 149. *Zizyphus Jujuba* Mill. Dict. ed. 8 (1768), no. 1 (*Z. sativa* Gaertn., *Z. vulgaris* Lam.); Merrill in Trans. Am. Phil. Soc. n.s. xxiv, pt. 2, 251 (1935).—Sibth. Fl. Graec. iii, t. 241; Hayne, Arzn. Gewächse, x, t. 43; P.C. 151; R. 799; Dr. 410; Tsch. ii, 60; H. 86.—Tr. 1023!—vide no. 490.

400. *Myxae vel Sebastae*, 199 r., cum ic. *Sebestena domestica* C.B.P. 446 a; J. 149. *Cordia Myxa* L. Sp. 190.—Delile, Fl. Egypte, 47, t. 19, ff. 1, 2; Hayne, Arzn. Gewächse, ix, t. 33; R. 432; Dr. 558; Tsch. ii, 61; H. 182.—Tr. 1021!

401. *Juiubae minores, Plinio Tuberes appellatae*, 199 r. sine ic. *Jujubae minores rotundae* C.B.P. 446 b. *Rhamnus Lotus* L. Sp. 194. *Zizyphus Lotus* (L.) Lam.—Spreng. Gesch. Bot. I, t. 3; Burnett, Pl. Util. ii, t. 33 a; R. 799; Dr. 411; Tsch. ii, 60.

402. *Folium Casiae*, 199 v., ic. 212 v., fig. sinistr.; Annot. Diosc. 3 v. *Tamalapatrum sive Folium* C.B.P. 409. (1) *Cinnamomum Cassia* Nees ex Blume (leaves); (2) *Cinnamomum Tamala* (Ham.) T. Nees et Eberm., and possibly other species.—vide no. 361.

The figure of the leaf is insufficient to determine the species concerned.

403. *Folia Caryophylli*, 199 v., sine ic. *Caryophyllus aromaticus* L. Sp. 515. *Eugenia caryophyllata* Thunb. (Clove leaves).—vide no. 381.

404 A. *Schoenus, vel teres odoratus iuncus, vel Schoenantus*, 199 v., excl. ic.; Annot. Diosc. 4 r. *Iuncus odoratus sive aromaticus* C.B.P. 11 a. *Andropogon Schoenanthus* L. Sp. 1046 (*Andropogon laniger* Desf.). *Cymbopogon Schoenanthus* (L.) Spreng.; Stapf in Kew Bull. 1906, 303, 352.—Hook. Ic. Pl. t. 1871; R. 71; Dr. 79; F.H. 728.

404 B. *Schoenus*, 200 r., quoad ic. tantum.—Not identified, but suggestive of Liliaceae rather than Gramineae.

405. *Nardus Indica*, 200 r., cum ic.; Annot. Diosc. 2 r. *Nardus* Garcia ab Horto, Arom. ed. 4, 129, ic. (1593). *Nardus Indica, quae spica, Spica nardi, et Spica Indica Officinis* C.B.P. 13 a. *Nardus Indica vulgaris* J. Bauh. Hist. III, pars 2, 202 b. *Nardostachys Jatamansi* DC. Coll. Mém. VII, 7, t. 1 (1832); Royle, Ill. 242–4, t. 54; Dymock, Warden and Hooper, Pharmacogr. Ind. II, 233.—Bot. Mag. t. 6564; R. 253; Dr. 645; H. 194.

406. *Nardus Celtica seu Saliunca*, 200 r., ic. 200 v.; Annot. Diosc. 2 r. *Nardus Celtica Dioscoridis* C.B.P. 165 a; C. 308; J. 53. *Valeriana foliis ovatis, obtusis, minime dentatis* Hall. Enum. 664. *Valeriana celtica* L. Sp. 32; Hegi, Ill. Fl. VI, pars 2, 269.—Plenck, Ic. Pl. Med. I, t. 29; Hayne, Arzn. Gewächse, IX, t. 28; R. 255; Dr. 644.

407. *Crethamum marinum sive Crethamum*, 200 v. *Crethamus*, ic. 201 r. *Crithmum sive Foeniculum maritimum minus* C.B.P. 288 a; J. 108; S. 54. *Crithmum maritimum* L. Sp. 246.—Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XXVII, t. 2788; R. 540; Dr. 494; H. 174.—*Crithmum* Matth. Comm. Diosc. 255 (1554)!

408 A. *Rha barbarum seu Indicum*, 201 r., excl. ic. *Rha barbarum* Annot. Diosc. 49 v. *Rhabarbarum Officinarum* C.B.P. 116 a. Una vel plures specierum sequentium:—(1) *Rheum officinale* Baill.—Bot. Mag. t. 6135; B.T. 213; Burkill, Dict. Econ. Prod. Mal. Penins. II, 1891, H. 161. (2) *Rheum palmatum* L. (sensu latiore).—B.T. 214; Bot. Mag. t. 9200; H. 161. (3) *Rheum emodi* Wall., *Rh. Moorcroftianum* Royle, *Rh. Webbianum* Royle; Royle, Ill. Bot. Himal. 316; Watt, Dict. Econ. Prod. India, VI, pt. 1, 485–8.

The Medicinal Rhubarb of modern commerce is probably the produce of at least two species, namely, *Rheum officinale* Baill. and *Rh. palmatum* L. As Cordus stated that *Rhabarbarum* was imported from India, the drug used in Europe in the sixteenth century may possibly have included also one or more of the Himalayan species listed under (3) e.g. *Rh. emodi* Wall., which according to Falconer (Trans. Linn. Soc. Lond., XIX, 28: 1842) grows in Kashmir in association with *Saussurea Lappa* (Decne.) C. B. Clarke (no. 410), and may have been collected for export along with it. On the other hand, both Garcia da Orta (Colloquies, ed. Markham, 390) and Linschoten (Hist. Navig. ed. gall. 177: 1610) state that the Rhubarb exported from India was brought from China through Tartary and Persia.

408 B. *Rhabarbaricum*, 201 r., ic. tantum. *Rhaponticum folio Lapathi majoris glabro* C.B.P. 117 a. *Rheum Rhaponticum* L. Sp. 371.—Hayne, Arzn. Gewächse, XII, t. 7; B.T. 215; P.C. 238; L.P. 12; R. 218; F.H. 500; Cristofoletti, Studien über Rheum rhaponticum (Bern, 1905); Tsch. II, 1392, fig. 378. tt. 60, 61; H. 161.

409 A. *Centaurium maius*, 201 r., excl. ic. 201 v. *Centaurium maius*, Annot. Diosc. 50 r., maxime. *Centaurium majus I. vulgare* Clus. Hist. II, p. x. *Centaurium majus folio in lacinias plures diviso* C.B.P. 117 a. *Centaurea Centaurium* L. Sp. 910.—Regn. Bot. II, t. 124; Oskamp, Artseny-Gewass. II, t. 136; Fiori e Paoletti, Iconogr. Fl. Ital. 447, no. 3742; R. 298; Dr. 686; Tsch. I. 540 (Expectorantia).—*Centaurium magnum* Matth. Comm. 315 (1554).—vide no. 478.

Stated by Cordus to grow abundantly on Monte Sant' Angelo in Italy. The inferior German kind mentioned by him was *Centaurea Rhapontica* L.—vide no. 409 B.

409 B. *Centaurium maius*, 201 v., ic. tantum. *Centaurium maius* Annot. Diosc. 50 r., partim. *Centaurium maius Germanicum*, Sylv. 223 v. *Centaurium maius, vulgo Rhaponticum: montanum genus primum, maioribus foliis, Lapathi aut Inulae fere*, Gesn. Hort. 252 r. *Rhaponticum folio Helenii incano* C.B.P. 117 b; C. 216. *Rhaponticum* Hall. Enum. 687. *Centaurea Rhapontica* L. Sp. 915 (*Rhaponticum scariosum* Lam.).—Bot. Mag. t. 1752; Fiori e Paoletti, Iconogr. Fl. Ital. 441, fig. 3716; Hegi, Ill. Fl. VI, pars 2, 932, fig. 630-2; R. 303; Dr. 687.

410. *Costus albus seu Arabicus*, 201 v., sine ic. *Arabicus Costus* Annot. Diosc. 4 r. *Costus Arabicus Dioscoridis* C.B.P. 36 a. *Aplotaxis auriculata* DC. in DC. Prodr. VI, 541 (1837). *Aplotaxis Lappa* Decne. in Jacquem. Voy. Bot. 96, t. 104 (1841-4). *Aucklandia Costus* Falc. in Trans. Linn. Soc. XIX, 23 (1842). *Saussurea Lappa* (Decne.) C. B. Clarke, Compos. Ind. 233 (1876); Watt, Comm. Prod. India, 980.—Basu, Ind. Med. Pl. t. 551 B; R. 1118; Dr. 685; Pharm. Journ. 1877, VIII, 41, 121; F.H. 382; Tsch. II, 1010; H. 39, 152.

411. *Costus flavus vel Syriacus*, 202 r., sine ic. *Syriacus Costus* Annot. Diosc. 4 r.—Not identified. Said to resemble *Costus albus*, except that the root is larger and yellow (like box-wood), sometimes with a reddish tinge.

412. *Inula Comagena*, 202 r., sine ic. *Helenium Comagenum* Annot. Diosc. 4 r. *Costus amarus Officinarum seu Helenium Comagenum Dioscoridis* C.B.P. 37 a.—Not identified. Exported from the East in substitution for the true *Costus albus* (no. 410). Resembling *Inula Helenium* L., but denser in texture. *I. Helenium* is not indigenous in Kommagene (N.W. Syria).

413. *Thapsia maior*, 202 r., ic. 202 v.; Annot. Diosc. 74 r. *Thapsia vera vel Turbit montis Gargani* Gesn. Hort. Germ. 284 r. *Thapsia carotae folio* C.B.P. 149 a. *Thapsia garganica* L. Mant. 57 (1765).—Sibth. Fl. Graec. III, t. 287; Bot. Mag. t. 6293; R. 550; Dr. 501; Tsch. III, 878.—*Thapsia* Matth. Comm. Diosc. 532 (1554)!

414. *Galanga maior*, 202 v., sine ic.; Annot. Diosc. I r., cap 2. *Galanga maior* C.B.P. 35 a. *Maranta Galanga* L. Sp. ed. 2, 3 (1762). *Alpinia Galanga* (L.) Sw. *Languas Galanga* (L.) Stuntz; Burkill, Dict. Econ. Prod. Mal. Penins.

II, 1306.—Rumph. Herb. Amboin. v, t. 63; Nees, Pl. Offic. I, tt. 67, 68; R. 132; Dr. 144; F.H. 643; H. 62.

\*415. *Galanga minor*, 202 v., sine ic. *Galanga*, et *Galanga minor officinarum* C.B.P. 35 b. *Alpinia officinarum* Hance in Journ. Linn. Soc., Bot. XIII, 6 (1873); et in Journ. Bot. 1873, 175. *Languas officinarum* (Hance) Farwell; Burkill, Dict. Econ. Prod. Mal. Penins. II, 1307.—Köhler, Med. Pfl. I, t. 9; Bot. Mag. t. 6995; B.T. 271; P.C. 110; Dr. 144; F.H. 641; Tsch. II, 1064; B.P.C. 474; H. 62.

416. *Acorus verus qui hodie . . . Calamus aromaticus appellatur*, 203 r., sine ic.; Annot. Diosc. I r. *Acorus verus, sive Calamus aromaticus Officinarum* C.B.P. 34 a, C. 209. *Acorus* Hall. Enum. 259; Hist. II, 164. *Acorus Calamus* L. Sp. 324; Dierbach in Flora, 1828, 545; Goepfert in Flora, 1830, 473; Kirschleger, Fl. Alsace, II, 210; Trimen in Journ. Bot. 1871, 163; Watt, Dict. Econ. Prod. India, I, 99; Commerce. Prod. India, 24; Burkill, Dict. Econ. Prod. Mal. Penins. I, 34.—Hayne, Arzn. Gewächse, VI, t. 31; Dietr. Fl. Boruss. XII, t. 830; B.T. 279; P.C. 50; R. 144; Dr. 102; F.H. 676; Tsch. II, 965; B.P.C. 241; H. 202.

The drug was imported from Asia, according to Cordus.

417. *Zingiber*, 203 r., sine ic.; Annot. Diosc. 47 r. *Zingiber* C.B.P. 35 a. *Amomum Zingiber* L. Sp. 1. *Zingiber officinale* Roscoe; Watt, Dict. Econ. Prod. India, VI, pt. 4, 358; Commerce. Prod. India, 1139; Burkill, Dict. Econ. Prod. Mal. Penins. II, 2296.—Jacq. Hort. Vindob. I, t. 75; Köhler, Med. Pfl. II, t. 202; B.T. 270; P.C. 115; R. 128; Dr. 141; F.H. 635; Tsch. II, 1045; B.P.C. 1130; H. 64.

418. *Zedoaria quae veteribus Arnabo et Zarnabum appellatur*, 203 r., sine ic. *Zedoaria longa* C.B.P. 35 a. *Zedoaire* Pomet, Hist. Gen. Drogues, I, 62 (1694). *Amomum Zedoaria* Berg. Mat. Med. 41 (1788). *Curcuma Zerumbet* Roxb. Cor. Pl. III, t. 201. *Curcuma Zedoaria* (Berg.) Roscoe; Watt, Dict. Econ. Prod. India, II, 669; Commerce. Prod. India, 444; K. Schum. in Engl. Pflanzenr. IV, 46 (Zingiberac.), 100; Burkill, Dict. Econ. Prod. Mal. Penins. I, 714 (Long Zedoary).—Roscoe, Monandr. Pl. t. 109; Köhler, Med. Pfl. I, t. 66; Valet. in Bull. Jard. Bot. Buitenz. sér. 2, XXVII, tt. 7 (fig. 1), 27; P.C. 312; R. 129; Dr. 143; Tsch. II, 1059; B.P.C. 380; H. 268.

419. *Zerumbetum*, 203 v., sine ic. *Zedoaria rotunda* C.B.P. 36 a. *Zerumbeth* Pomet, Hist. Gen. Drogues, I, 62 (1694). *Curcuma Zedoaria* (Berg.) Roscoe (Round Zedoary).—vide praec.

420. *Curcuma longa*, 203 v., sine ic. *Cyperus genus ex India* C.B.P. 37 a. *Curcuma longa* Koenig in Retz. Obs. III, 72 (1783); et auct. mult.; non L. (1753). *Curcuma domestica* Valet. in Bull. Jard. Bot. Buitenz. sér. 2, XXVII, 31, tt. 4 (fig. 1), 22 (1918); Burkill, Dict. Econ. Prod. Mal. Penins. I, 706 (Long Turmeric).—P.C. 287; R. 129; Dr. 142; F.H. 638; Tsch. III, 909; (all as *Curcuma longa* L.); B.P.C. 379.

421. *Curcuma rotunda*, 203 v., sine ic. *Curcuma domestica* Valet. (Round Turmeric).—vide praec.

422. *Doronicum*, 203 v., sine ic. *Doronicum Romanum* Gesner, loc. cit., in lemmate. *Aconitum pardalianches minus* Matth. Epit. 824 (1586). *Doronicum radice scorpii* C.B.P. 184 a; J. 61. *Doronicum Pardalianches* L. Sp. 885 (excl. var.  $\alpha$ ); Hegi, Ill. Fl. vi, pars 2, 718.—Jacq. Fl. Austr. iv, t. 350; Hayne, Arzn. Gewächse, vi, t. 21; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxix, t. 3067; R. 292; Dr. 683.—*Doronicum Romanum* Dod. Imag. ed. 2, II, 445 (1559).

423. *Turbitum*, 204 r., sine ic. *Alexandrinum officinarum Turbith* Lobel, Kruidtboeck, 452 (1581); Ic. 371. *Turpetum Arabum, seu Turbit Officinarum* C.B.P. 149 a. *Convolvulus Turpethum* L. Sp. 155. *Ipomoea Turpethum* (L.) R. Br. *Operculina Turpethum* (L.) Silva Manso; Watt, Dict. Econ. Prod. India, iv, 493; Comm. Prod. India, 822.—Plenck, Ic. Pl. Med. II, t. 105; Bot. Reg. iv, t. 279; Bot. Mag. t. 2093; Hook. Bot. Misc. III, 297, Suppl. t. 38; P.C. 287; R. 443; Dr. 555; Tsch. II, 1337; B.P.C. 1083; H. 228.

424. *Thapsia minor*, 204 r., sine ic.—An unidentified species of Umbelliferae: 'Thapsia minor, aequae ut maior, ex umbelliferarum et ferulacearum herbarum genere est.' Unlike *Thapsia maior* (no. 413), the dried root, when first tasted, was insipid, and only after a time conveyed an acrid and burning sensation to the tongue and palate. The pith was filled with drops of reddish dried liquid: 'medulla . . . liquorem ruffum, exiccatum, guttatim dispersum continens.'

425. *Mandragoras albus seu masculus*, 204 r. *Mandragoras albus*, 204 v., ic. *Mandragoras mas* Annot. Diosc. 67 v. *Mandragora fructu rotundo* C.B.P. 169 a; C. 309; J. 55. *Mandragora* L. Hort. Cliff. 57, partim. *Mandragora officinarum* L. Sp. 181, partim. *Atropa Mandragora* L. Sp. ed. 2, 259, partim. *Mandragora mas* Garsault, Descr. Pl. Anim. III, 221, t. 363 (1767), incidental binomial; Vierhapper in Oesterr. Bot. Zeitschr. 1915, LXV, 124. *Mandragora acaulis* Gaertn. Fruct. II, 237 (1791), illegitimate name. *Mandragora vernalis* Bertol. Virid. Bonon. Veg. 6 (1824); Comm. Mandrag. 9, t. I (1835); Fl. Ital. II, 618 (1835); Dunal in DC. Prodr. XIII, pars 1, 466 (1852); Fiori e Paoletti, Fl. Anal. Ital. II, 405 (1902), & ed. 2, II, 316 (1926).—R. 466; Dr. 597; Tsch. III, 306 (as *M. officinarum* L.).—F. 300; Tr. 890!

The following characters in the description indicate *M. vernalis*: 'folia . . . in viridi candicantia'; 'poma figura rotunda, parvis limonibus aequalia, colore ad dilutum aqua crocum inclinantia'; 'radice foris candida aut in pallido subfusca.'

*M. mas* Garsault is illegitimate because it was published in a work in which the Linnaean system of binary nomenclature was not consistently employed. *M. acaulis* Gaertn. is illegitimate, being a superfluous name for *M. officinarum* L., which it was intended to replace. Hence the name *M. vernalis* Bertol. is adopted for this species.



426 A. *Mandragoras niger seu foemina*, 204 v., excl. ic. *Mandragoras foemina* Annot. Diosc. 67 v. \**Mandragora autumnalis* Bertol. Elench. Pl. Viv. 6 (1820); Vierhapper in Oesterr. Bot. Zeitschr. 1915, LXV, 128.—*Mandragora microcarpa* Bert. Comm. Mandrag. 12, t. 3 (1835); Fl. Ital. II, 622 (1835); Dunal in DC. Prodr. XIII, pars 1, 467 (1852). *Mandragora autumnalis* var. *microcarpa* (Bertol.) Fiori e Paoletti, Fl. Anal. Ital. II, 405 (1902), & ed. 2, II, 316 (1926).—R. 466; Dr. 597.

The following characters indicate *M. autumnalis* Bertol.: 'folia in viridi colore nigricantia'; 'poma sunt albo Mandragorae . . . duplo minora . . . mespilis nostratibus aequalia'; 'radicem foris nigricantem.'

426 B. *Mandragoras foemina*, 204 v., quoad ic. tantum. *Mandragora fructu pyri* C.B.P. 169 a. *Mandragora* L. Hort. Cliff. 57, partim. *Mandragora officinarum* L. Sp. 181, partim; emend. Bertol. Virid. Bonon. Veg. 6 (1824); Comm. Mandrag. 10, t. 2 (1835); Fl. Ital. II, 620 (1835); Dunal in DC. Prodr. XIII, pars 1, 466 (1852).—*Atropa Mandragora* L. Sp. ed. 2, 259, partim. *Mandragora foemina* Garsault, Fig. Pl. Anim. III, 221, t. 363, fig. a, 2, foemina (1767), incidental binomial; Vierhapper in Oesterr. Bot. Zeitschr. 1915, LXV, 134. *Mandragora autumnalis* Bertol. sec. Spreng. Syst. I, 699 (1825), non Bertol. (1820). *Mandragora autumnalis* var. *typica* Fiori e Paoletti, Fl. Anal. Ital. II, 405 (1902), & ed. 2, II, 316 (1926).—R. 466; Dr. 597; Tsch. III, 306 (as *M. autumnalis* Spreng.).

The shape of the fruits shown in the figure indicate *M. officinarum* L. em. Bertol. (1824).

427. *Macholebum seu Mahaleb*, 204 v. *Macholebum*, 205 r., ic. *Chamaecerasus* . . . quae Arabicè Mahaleb dicatur Gesn., 214 r. *Mahaleb* Matth. Epit. 91 (1586). *Chamaecerasus Matthioli* Dalech. Hist. I, 201 (1587). *Ceraso affinis* C.B.P. 451 b; J. 150. *Cerasus silvestris amara Mahaleb putata* J. Bauh. Hist. I, pars 1, 227 a (1650). *Prunus Mahaleb* L. Sp. 474.—Jacq. Fl. Austr. III, t. 227; Reichb. Ic. Fl. Germ. xxv, t. 94; R. 976; Dr. 285; H. 102.—vide no. 469.

The figure was drawn from a fruiting branch sent to Gesner by Dalechamps (214 r.).

428. *Cuminum sativum*, 205 r., cum ic. *Cuminum sativum* Annot. Diosc. 54 v. *Cuminum semine longiore* C.B.P. 146 a; J. 44. *Cuminum Cuminum* L. Sp. 254.—Hayne, Arzn. Gewächse, VII, t. 11; B.T. 134; L.P. 137; R. 549; Dr. 499; F.H. 331; H. 44.—Br. 190; Tr. 876!

429. *Brassica marina*, 205 v., cum ic. *Brassica marina* Matth. Epit. 253 (1586). *Soldanella maritima minor* C.B.P. 295 a; C. 729; J. 111; S. 56. *Convolvulus Soldanella* L. Sp. 159. *Calystegia Soldanella* (L.) R. Br.—Hayne, •Arzn. Gewächse, XII, t. 37; R. 441; Dr. 557.—*Brassica marina* Dod. Cruydeb. 429 (1554).

430. *Absinthium Seriphium, sive marinum Absinthium*, 205 v., sine ic. *Santonicum, semen sanctum* (*Semen Cini*) Lonic. Kreuterbuch, 183 A (1578). *Absinthium Santonicum Alexandrinum* C.B.P. 139 b. *Artemisia Cina* Berg.—Köhler, Med. Pfl. i, t. 20; P.C. 307; Dr. 678; F.H. 388; Tsch. II, 1013; B.P.C. 925; H. 176.

*Cina* Forsk. Mat. Med. Kahirina, 156, no. 58 (1775), was stated to be imported from Persia via Syria. *Santonica* (*Semen Contra*, *Semen Cinae*, Wormseed) consists of the dried unexpanded capitula of *Artemisia Cina*, a native of Turkestan. Cordus stated that *Alexandrinum semen* (*Zinae semen*) grew in maritime places in Egypt, whence it was imported into Germany. This statement probably refers to *Artemisia judaica* L., a native of Egypt and Arabia Petraea, from which worm powder is obtained according to Blatter (Rec. Bot. Surv. India, VIII, 256: 1921). *A. judaica* may have been imported into Germany in the time of Cordus as an adulterant of the true *Semen Cini*, or as a substitute for it.

431. *Bdellium*, 205 v., sine ic.; Annot. Diosc. 14 v. *Bdellium* C.B.P. 503 a. *Commiphora* spp., incl. *C. africana* (A. Rich.) Engl. and *C. Mukul* (Hook.) Engl.

Cordus stated that *Bdellium* was obtained from a tree growing in Arabia, India, and neighbouring regions, with a bark resembling that of a cherry-tree. African *Bdellium* appears to be yielded by *C. africana* (A. Rich.) Engl. and other species—vide R. 862; Kew Bull. 1896, 91; Engl. u. Prantl, Nat. Pflanzenf. ed. 2, XIX. A, 443; Index Minor Forest Prod. Brit. Empire, 52 (1936); Dalziel, Useful Pl. W. Trop. Afr. 316; H. 122. Indian *Bdellium* is the produce of *C. Mukul* (Hook.) Engl. (*Balsamodendron Mukul* Hook. in Hook. Journ. Bot. I, 258, t. 8: 1849).—vide R. 862; Gamble, Man. Indian Timbers, ed. 2, 139 (1902); Watt, Commere. Prod. India, 400 (1908); H. 115.

Cordus described six kinds of *Bdellium* imported into Germany in his day, and differing in form and size, mode of fracture, consistency, colour, transparency, taste, and smell; the identification of these must be left to the pharmacognosist.

432. *Myrrha*, 206 r., sine ic.; Annot. Diosc. 14 r. *Myrrha* C.B.P. 501 b. *Commiphora Myrrha* var. *Molmol* Engl. in Engl. Jahrb. xv, 95 (1892). *Commiphora Molmol* Engl. apud Tschirch, Handb. Pharmakogn. III, 1117 (1925); Engl. in Engl. u. Prantl, Nat. Pflanzenf. ed. 2, XIX. A, 436, fig. 206 (1931).—P.C. 196; B.P.C. 663; H. 117.

433. *Stacte*, 206 r., sine ic. *Stacte* Annot. Diosc. 13 v. *Stacte* C.B.P. 502 a. *Commiphora Molmol* Engl. (Oil obtained by pressure from myrrh.)

Prepared by Cordus himself. Flückiger and Hanbury, Pharmacogr., ed. 2, 142 (1879), state that no drug of modern times has been identified with the stacte or liquid myrrh of the ancients. They cite Pliny and Theophrastus, but appear to have overlooked the statement of Dioscorides, Mat. Med., ed. Sprengel, I, 75 (lib. i. cap. 73) that stacte was obtained from myrrh by pressure.

434. *Opobalsamum*, 206 v., sine ic. *Balsamum Syriacum rutae folio* C.B.P. 400 a. *Amyris Opobalsamum* L. Diss. Opobals. 14 (1764); Mant. 65 (1767); Amoen. Acad. vii, 69 (1769); Mat. Med. ed. 2, 101 (1773). *Amyris gileadensis* L. *Balsamodendron Opobalsamum* (L.) Kunth. *Commiphora Opobalsamum* (L.) Engl. (Oil).—B.T. 59; R. 861, 862; Dr. 368; H. 10, 117.—vide nos. 362, 388.

435. *Canchamum*, 206 v., sine ic. *Cancamum* Annot. Diosc. 9 r. *Lacca officinarum* C.B.P. 499 a. *Tachardia lacca* Kerr; Watt, Commere. Prod. India, 1053 (Lac.).

436. *Sarcocolla*, 207 r., sine ic.; Annot. Diosc. 57 r. *Sarcocolla* C.B.P. 498 a. *Astragalus* sp.? Dymock in Pharm. Journ. ser. 3, ix, 735 (1879); Dymock, Veg. Mat. Med. W. India, ed. 1, 235 (1883), & ed. 2, 288 (1885). *Astragalus Sarcocolla* Dymock in Dymock, Warden and Hooper, Pharmacogr. Ind. i, 476 (1890); Tsch. iii, 780. *Astragalus fasciculifolius* Boiss. Diagn. Pl. Nov. ii, 73 (1843); Boiss. Fl. Or. ii, 396 (1872); D. Hooper in Journ. As. Soc. Beng. n.s. ix, 177 (1913); & in Kew Bull. 1931, 306 (*Sarcocolla*).—H. 71.

437. *Benzoum seu Benzoi*, 207 r., sine ic. *Belzoinum officinarum* C.B.P. 503 a. *Styrax Benzoin* Dryander in Phil. Trans. LXXVII, 308, t. 12 (1787); Perkins in Engl. Pflanzenr. iv, 241 (*Styracaceae*), 59, fig. 7 (1907) (*Benzoin officinale* Hayne) (Sumatra Benzoin).—Hayne, Arzn. Gewächse, xi, t. 24; B.T. 169; P.C. 25; R. 513; F.H. 403; Tsch. iii, 1013; H. 11, 70.

438. *Benzoinum oleum*, 207 r., sine ic. *Styrax Benzoin* Dryand.—vide praec. An oil obtained from Benzoin by pressure or distillation.

439. *Cinnabari*, id est, *Sanguis draconis*, 207 r., sine ic. *Sanguis draconis officinarum* C.B.P. 499 a. *Dracaena* spp. seq. (Dragon's blood): (1) *Dracaena Cinnabari* I. B. Balf. in Trans. Roy. Soc. Edin. xxx, 623 (1882); Dobbie and Henderson, ibid. 624, and in Pharm. Journ. ser. 3, xiv, 361, 372 (1883); I. B. Balf. loc. cit. xxxi, 293, tt. 96, 97 (1888); Tsch. iii, 1067; Burkill, Dict. Econ. Prod. Mal. Penins. i, 748, 857; H. 52. (2) *Dracaena Draco* L.

The Dragon's blood imported into Germany in the time of Cordus was apparently obtained partly from *Dracaena Cinnabari* (Socotra) and partly from *D. Draco* (Madeira and Canaries). Cordus stated that Cinnabari was the produce of an African tree. Clusius, Hist. Pl. i, 2 (1601), wrote that a large part of the Dragon's blood stocked by druggists of his day was imported from Madeira and the Canaries, and some possibly from Africa.

The Dragon's blood of modern commerce is the produce of *Daemonorops Draco* (L.) Blume (Sumatra), and other species of *Daemonorops*, and was first mentioned by Acosta, Tract. Drog. Ind. Or. 118 (1578), who stated that it was imported into Spain.

440. *Propolis*, 207 v., sine ic.; Annot. Diosc. 41 v. Bee-glue, a resinous substance collected by bees from the buds of species of *Populus* and *Betula*. Cordus distinguished four kinds,

441. *Styrax*, 207 v., sine ic. *Storax calamita*, 208 r. *Styrax* (sive *Storax officinarum*) C.B.P. 502 a. *Styrax officinalis* L. Sp. 444 (True Storax).—vide no. 370 A.

442. *Styrax liquidus*, 207 v., sine ic. *Liquida Styrax* Annot. Diosc. 14 v. *Styrax liquidus* C.B.P. 502 b. (1) *Liquidambar orientalis* Mill. (Liquid Storax).—vide nos. 363, 370 C. (2) *Styrax officinalis* L.—vide no. 370 A.

In his 'Annotationes', 14 v., Cordus stated that there were two kinds of liquid *Styrax*:—(1) a resinous exudation obtained either (A) from the tree [*Liquidambar orientalis*], or (B) by a process of cooking ('coctura'); (2) a kind obtained by pressure from *Styrax* kernels [*Styrax officinalis*]. In his 'Historia', 208 r., he stated that liquid *Styrax* [1 B] was made by cooking a little *Storax calamita* [*Styrax officinalis*] together with a larger quantity of larch resin, oil, and wine. From this mixture two substances were separated, namely, Liquid *Styrax* and Oil of *Styrax*. It follows that there were actually three different kinds of Liquid *Styrax* in his day.

443. *Thus vel Olibanum*, 208 r., sine ic.; Annot. Diosc. 14 v. *Thus sive Olibanum officinarum* C.B.P. 501 a. *Boswellia* spp. incl. *B. Carterii* Birdw. and *\*B. serrata* Roxb. (Frankincense, Olibanum).

Cordus mentioned several different kinds. Arabian Olibanum is the produce of *Boswellia Carterii* Birdw. in Trans. Linn. Soc. xxvii, 143, tt. 29, 30 (1870); F.H. 134; B.T. 58; Dr. 366; B.P.C. 749; H. 125. Indian Olibanum is obtained from *Boswellia serrata* Roxb. ex Colebr. in Asiat. Res. ix, 379, t. 5 (1807); R. 859; Dr. 367; Watt, Commere. Prod. India, 174 (1908).

444. *Terebinthina resina sive Terebinthi*, 208 v., sine ic. *Terebinthus* Annot. Diosc. 15 v. *Terebinthus vulgaris* C.B.P. 400 a; J. 144; S. 72. *Terebinthina vera* C.B.P. 500 a. *Pistacia Terebinthus* L. Sp. 1025; Engl. in DC. Monogr. Phan. iv, 288 (Chian or Cyprian Turpentine).—Hayne, Arzn. Gewächse, xiii, t. 19; Sibth. Fl. Graec. x, t. 956; B.T. 69; R. 846; Dr. 395; F.H. 165; H. 29, 213.

445. *Masticha seu Mastiche vel Mastix*, 208 v., sine ic. *Lentiscus vulgaris* C.B.P. 399 a; J. 144; S. 72. *Resina lentiscina sive Mastiche* C.B.P. 501 a. *Pistacia Lentiscus* L. Sp. 1026; Engl. in DC. Monogr. Phan. iv, 285 (Mastic).—Hayne, Arzn. Gewächse, xiii, t. 20; Sibth. Fl. Graec. x, t. 957; B.T. 68; P.C. 183; R. 846; Dr. 396; F.H. 161; Tsch. iii, 1138; B.P.C. 633; H. 108.

446. *Sandarax*, 208 v., sine ic. *Sandaracha vel melius Sandarax* Annot. Diosc. 81 v. *Gummi Juniperi* C.B.P. 500 b. *Thuja articulata* Vahl, Symb. Bot. ii, 96 (1791). *Callitris quadrivalvis* Vent. (1808). *Tetraclinis articulata* (Vahl) Mast. (Sandarac); Pilger in Engl. u. Prantl, Pflanzenfam. ed. 2, xiii, 381.—Köhler, Med. Pfl. i, t. 31; R. 166; Dr. 72; Tsch. iii, 1143; B.P.C. 923; H. 175, 214,

447. *Resina Elemnia*, 208 v., sine ic. *Gummi Elemi officinarum* C.B.P. 504 a. *Boswellia Frereana* Birdw. in Trans. Linn. Soc. Lond. xxvii, 146, t. 32 (1870) (East African Elemi).—F.H. 135, 148; Dr. 367; B.P.C. 405.

448. *Colophonias vel Pix Graeca*, 209 r., sine ic.; Annot. Diosc. 15 v., cap. 93; *Colophonias officinarum* C.B.P. 504 a. *Pinus* sp. (Colophony).

Colophony is the residue left after the removal, by distillation, of the oil of turpentine, from the crude oleo-resin obtained from various species of *Pinus*.—vide B.P.C. 351; H. 227.

Cordus (Annot. Diosc. 15 v.) did not know the source of Colophonias: 'Habent tamen adhuc Colophonias nomine siccissimam resinam, quae an Brutia, aut Cedri pix sit nondum ausum certo affirmare.'

Brutia pix (Calabrian pitch) was presumably obtained from the Calabrian Pine, *Pinus halepensis* var. *brutia* (Ten.) Henry.

449. *Larigna resina*, 209 r., sine ic.; Annot. Diosc. 15 v., cap. 93. *Larix* C.B.P. 492; J. 161. *Resina laricea* C.B.P. 500 b. *Pinus Larix* L. Sp. 1001. *Larix decidua* Mill. (*L. europaea* DC.) (Venice Turpentine).—B.T. 260; P.C. 159; R. 171; Dr. 66; F.H. 609; Tsch. iii, 1144; H. 228.—vide no. 337.

450. *Ladanon*, 209 r., sine ic.; Annot. Diosc. 20 r. *Ladon* Annot. Diosc. 20 r. *Cistus ledon Cretense* C.B.P. 467 a. *Cistus creticus* L. Syst. ed. 10, 1077 (1759), and Sp. ed. 2, 738 (*Ladanum*).—B.T. 24; R. 655; Dr. 446; H. 92.

The principal source of *Ladanum* is *Cistus creticus* L., but the drug is obtained also from *C. ladaniferus* L., *C. laurifolius* L., and *C. salvifolius* L.

451. *Gummi Arabicum*, 209 r., sine ic. *Gummi Arabicum* C.B.P. 498 a. *Acacia* spp. seq. (Gum Arabic): (1) *Acacia arabica* (Lam.) Willd. Sp. iv, 1085 (1806); Holland in Kew Bull., Add. Ser. ix, 288. (2) *Acacia Senegal* Willd. loc. cit. 1077 (1806); Holland, loc. cit. 293.—B.T. 94; P.C. 1; F.H. 233; Tsch. ii, 407; B.P.C. 3; Dalziel, Useful Pl. W. Trop. Afr. 202, 207.

452. *Tragacanthum*, 209 v., sine ic.; Annot. Diosc. 51 v. *Gummi tragacanthum* C.B.P. 498 a. *Astragalus gummifer* Labill. in Obs. Phys. xxxvi, 59, t. 1 (1790), and other species.—Hayne, Arn. Gewächse, x, t. 8; B.T. 73; P.C. 285; R. 1002; Dr. 322; F.H. 174; Tsch. ii, 388; H. 71.

453. *Laserpicium sive Assa foetida*, 209 v., sine ic.; Annot. Diosc. 56 v. *Laserpitium veterum* C.B.P. 156 a. *Ferula* spp. incl. *F. foetida* (Bunge) Regel in Act. Hort. Petrop. v, 590 (1877), and *F. alliacea* Boiss. Fl. Or. ii, 995 (1872).

*Ferula Assa-foetida* L. Sp. 248 has been identified by Boissier (loc. cit. 994) and Tschirch (Pharmakogn. iii, 1076) with *F. foetida* Regel, and by Falconer (Trans. Linn. Soc. Lond. xx, 285) with a Kashmir species which he described under the name *Narthex Assafoetida* (L.) Falc. Flückiger and Hanbury, Pharmacogr. ed. 2, 315, and Bentley and Trimen, Med. Pl. 127, considered that *F. Assa-foetida* could not be identified with certainty with either of these species.

According to Watt, *Commerc. Prod. India*, 534, *Ferula foetida* Regel (*F. Scorodosma* Benth. et Trim.) yields the true Asafetida of modern European commerce—vide B.T. 127; P.C. 15; F.H. 314; Tsch. III, 1076; B.P.C. 165; H. 8.

454. *Sagapenum sive Serapinum*, 209 v., sine ic.; Annot. Diosc. 56 v. *Sagapenum* C.B.P. 494 b. *Ferula* sp.—F.H. 324; Tsch. III, 1104; Hooper in Kew Bull. 1931, 317; B.P.C. 167; H. 71.

455. *Galbanum*, 209 v., sine ic.; Annot. Diosc. 57 r. *Galbanum* C.B.P. 494 a. *Ferula* spp. incl. *F. galbaniflua* Boiss. et Buhse in Nouv. Mém. Soc. Nat. Mosc. XII, 99 (1860) (*Galbanum*).—B.T. 128; P.C. 111; F.H. 321; Dr. 495; Watt, *Commerc. Prod. India*, 535; Tsch. III, 1096; Hooper in Kew Bull. 1931, 317; B.P.C. 475; H. 62.

456. *Hammoniacum, seu gutta Hammoniaci*, 210 r., sine ic.; Annot. Diosc. 57 r. *Ammoniacum* C.B.P. 494 a. *Dorema Ammoniacum* D. Don in Trans. Linn. Soc. Lond. XVI, 602 (1833) (*Ammoniacum*).—B.T. 131 (sphalm. '130'); P.C. 9; R. 544; Dr. 497; F.H. 324; Tsch. III, 1108; B.P.C. 103; H. 5, 70.

The description of *Hammoniacum* given by Cordus agrees fairly well with *Ammoniacum*, a gum-resin obtained from *Dorema Ammoniacum* D. Don, a native of Persia, Afghanistan, and Turkestan.

*Ammoniacon* Diosc. (*Mat. Med.* ed. Spreng. I, 439), as figured in Codex Vindob. fol. 45 v., agrees with *Ferula marmarica* Aschers. et Taub. (Cyrenaica), according to Stapf in Kew Bull. 1907, 382. The Gum Ammoniac of Morocco, on the other hand, is the produce of *Ferula communis* var. *brevifolia* Mariz—vide Stapf in Bot. Mag. t. 8157; B.P.C. 103.

457. *Opopanax, sive Opopanacum*, 210 r., sine ic.; Annot. Diosc. 54 r., cap. 55. *Opopanax* C.B.P. 494 b. *Opopanax* spp. seq.: (1) *Laserpitium Chironium* L. Sp. 249. *Opopanax Chironium* (L.) Koch.—Nees, Pl. Offic. II, t. 292; Reichb. Ic. Fl. Germ. XXI, t. 943; R. 542; Dr. 495; F.H. 327; Tsch. III, 1106. (2) *Pastinaca Opopanax* L. Sp. 262. *Opopanax orientale* Boiss. in Ann. Sc. Nat. sér. 3, I, 330 (1844); Boiss. Fl. Or. II, 1059.—Sibth. Fl. Graec. III, t. 288.

*Opopanax* was imported from Africa, Egypt, and Asia Minor, according to Cordus. The African kind was probably yielded by *Opopanax Chironium*, while that from Asia Minor may have been the produce of *O. orientale*.

458. *Opium*, 210 r., sine ic.; Annot. Diosc. 66 r., cap. 65. *Opium* C.B.P. 494 b. *Papaver somniferum* L. Sp. 508 (*Opium*).—B.T. 18; P.C. 226; R. 625; Dr. 249; F.H. 40; Tsch. II, 563, & III, 593; B.P.C. 750; H. 110, 126.—Br. 227; F. 294.

459. *Euphorbia*, 210 v., sine ic. *Euphorbium* Annot. Diosc. 56 v. *Euphorbium* C.B.P. 387 a. *Euphorbia resinifera* Berg in Berg u. Schmidt, Darst. Beschreib. Offic. Gewächse, t. 34 d, fig. m-x (1863).—B.T. 240; P.C. 101; Dr. 385; F.H. 558; Tsch. III, 1167; B.P.C. 430; H. 58.

460 A. *Scammonium sive Scammonaea*, 210 v., ic. 210 bis, r., fig. dextra; Annot. Diosc. 75 r., cap. 171. *Scammonia Syriaca* C.B.P. 294 a; J. 110; S. 55. *Convolvulus Scammonia* L. Sp. 153 (Scammony).—B.T. 187; P.C. 251; R. 441; Dr. 553; F.H. 438; Tsch. II, 1333; B.P.C. 561, 935; H. 180.

460 B. *Scammonium*, 210 bis, r., fig. sinistra.—Not identified.

461. *Aloe*, 210 bis, r., ic. 210 bis v.; Annot. Diosc. 51 v. *Aloe* C.B.P. 495 a. *Aloë vulgaris* C.B.P. 286 a. *Aloë* spp. seq.: (1) \**Aloë Perryi* Baker in Journ. Linn. Soc. Lond., Bot. XVIII, 161 (1881), and in Bot. Mag. t. 6596; I. B. Balf. in Trans. Roy. Soc. Edin. XXXI, pp. xxxviii, 291, 444 (Socotrine Aloes).—Tsch. II, 1424; H. 4. (2) *Aloë perfoliata* var. *vera* L. Sp. 320, and ed. 2, 458. *Aloë barbadensis* Mill. Gard. Dict. ed. 8, no. 2 (1768).—Engl. Pflanzenr. IV. 38. III, II (Liliac.—Asphodel.—Aloin.), 228, fig. 84; P.C. 7; R. 89 (*A. vulgaris* Lam.); F.H. 679; Watt, Commenc. Prod. India, 59; Tsch. II, 1422; B.P.C. 91; H. 4.—Tr. 932!

Cordus described three kinds of *Aloe*, namely *Succotrina*, *Hepatica*, and *Caballina*. Of these, the first was probably *Aloë Perryi* and the second *Aloë barbadensis*. Linnaeus treated the plant afterwards called *Aloë vera* (by Willdenow, Sp. II, 186) as a variety of *A. perfoliata*, as is indicated by the Roman type in which the name 'vera' is printed, and by the provision of the varietal letter  $\pi$  in Sp. Pl. ed. 2. The correct name for the species appears to be *Aloë barbadensis* Mill. The figure, taken from Tragus, represents *A. barbadensis*.

462. *Sacharum sive Zuccharum*, 210 bis, v., ic. 211 r.; Annot. Diosc. 36 r. *Arundo Saccharifera* C.B.P. 18 b. *Saccharum officinarum* L. Sp. 54 (Cane Sugar).—B.T. 298; R. 69; Dr. 78; F.H. 714; Tsch. II, 117; B.P.C. 1025; H. 199.

Cordus distinguished seven kinds of Sugar, according to their places of origin and method of preparation.

463. *Drosomeli, id est, Manna*, 211 v., sine ic. *Aërium seu roscidum mel* Annot. Diosc. 14 v., cap. 85. *Mel* [quod] ex aëre descendit Annot. Diosc. 35 v.:—(1) quod in calidioribus locis, veluti Arabia ac Syria gignitur. *Manna officinarum* C.B.P. 497 a. *Fraxinus Ornus* L. Sp. 1057.—B.T. 170; P.C. 179; R. 360; Dr. 524; F.H. 409; Tsch. II, 103; B.P.C. 630; H. 8, 106. (2) quod apud nos in Germania decedit. Honey-dew, a sugary liquid produced on the leaves of trees by the punctures of Aphides.

According to Cordus, two kinds of Manna were stocked by the druggists in his day, both from Calabria: Manna Granata was in the form of small grains, and Manna Masticina in larger pieces.

464. *Chinaea radix sive China*, 212 r., sine ic. *China radix* C.B.P. 296 a; S. 56. *Smilax China* L. Sp. 1029.—Nees, Pl. Offic. I, t. 45; P.C. 68; R. 102; Dr. 129; F.H. 712; Tsch. II, 1516.

465. *Elaeagnus Cordi*, ic. 212 v., sine descr. *Elaeagnus Theophrasti* Annot. Diosc. 20 b. *Rhus myrtifolia Belgica* C.B.P. 414 b ; J. 145. *Myrica Gale* L. Sp. 1024.—Syme, Engl. Bot. VIII, t. 1298 ; P.C. 111 ; R. 181 ; Dr. 161 ; Tsch. III, 830.

### Appendix.

\*466. *Tulipa Turcarum* Gesn., 213 r. *Tulipa praecox rubra* C.B.P. 57 a ; J. 19. *Tulipa Gesneriana* L. Sp. 306.—Trew, Hist. Amoen. Fl. Imag. tt. 52, 55, 59.

The plant actually seen by Gesner had a flower with 8 perianth leaves and as many stamens. The figure reproduced by Gesner was sent to him previously by a friend.

467. *Alia herba . . . Turcico Tulipae nomine . . . cuius picturam Ioan. Kentmannus nobis communicavit* Gesn., 213 v. *Tulipa praecox lutea* C.B.P. 57 a ; J. 19. *Tulipa Gesneriana* L. Sp. 306.

\*468. *Chamaecerasus montana*, 213 v. *Chamaecerasus alpigena* Lob. Hist. 593 (1576). *Xylosteum alterum* Dod. Stirp. Hist. Pempt. 407 (1583). *Ficus Idaea* Dalech. Hist. I, 199, ic. 200 (1587). *Chamaecerasus alpina fructu rubro gemino, duobis punctis notato* C.B.P. 451 a ; C. 746. *Caprifolium floribus geminis, foliis oblonge ovatis, integerrimis* Hall. Enum. 464. *Chamaecerasus* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. i, 33, t. 14, no. 43 (1759). *Lonicera alpigena* L. Sp. 174.—Jacq. Fl. Austr. III, t. 274 ; Guimpel, Willd. u. Hayne, Abbild. Deutsch. Holzart. I, t. 10 ; R. 352 ; Dr. 643.

Burser appears to have misinterpreted *Chamaecerasus alpina fructu rubro gemino, duobus punctis notato* C.B.P. and *Chamaecerasus dumetorum fructu gemino rubro* C.B.P., applying the former to *Lonicera Xylosteum* L. and the latter to *L. alpigena* L., instead of vice versa (teste J. 150).

469. *Chamaecerasus Dalechampii . . . quae Arabice Mahaleb dicatur* Gesn., 214 v., ic. 205 r. (*Macholebum*). *Ceraso affinis* C.B.P. 451 a ; J. 150. *Prunus Mahaleb* L. Sp. 474.—vide no. 427.

\*470. *Chamaemespilus* Gesn., 214 v., ic. 215 r. (*Chamaemespilum*). *Chamaemespilus Cordi* Th. 33 ; Sch. 51. *Chamaemespilus Cordi* C.B.P. 452 a. *Mespilus foliis ovatis integerrimis* Hall. Enum. 352. *Chamaemespilus* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 1, t. 15, no. 51 (1770). *Mespilus Cotoneaster* L. Sp. 479. *Cotoneaster integerrimus* Medik. (*C. vulgaris* Lindl.).—Guimpel, Willd. u. Hayne, Abbild. Deutsch. Holzart. I, t. 71 ; Dietr. Fl. Boruss. VII, t. 448 ; Reichb. Ic. Fl. Germ. xxv, t. 96 ; R. 949 ; Dr. 272.

\*471. *Chamaenerion, prima et vulgaris species* Gesn., 215 r. *Lysimachia siliquosa glabra major* C.B.P. 245 a ; S. 44. *Epilobium foliis ex ovatis lanceolatis, serratis, levissime hirsutis* Hall. Enum. 409. *Epilobium montanum* L. Sp. 348 ; Hausskn. Monogr. Epilobium, 74, 76.—Reichb. Pl. Crit. II, t. 189 ; Zenker, Fl. Thüringen, I, t. 73.



\*472. *Chamaenerion*, altera species Gesn., 215 v. *Lysimachia siliquosa glabra minor* C.B.P. 245 b. *Epilobium foliis ex ovatis lanceolatis, serratis, levissime hirsutis* Hall. Enum. 409, var.  $\beta$ . *Epilobium minus flore albo* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 30, t. 20, no. 73. *Chamaenerion roseum* Schreb. Spicil. Fl. Lips. 147 (1771). *Epilobium roseum* Schreb. loc. cit., Addenda, fol. K 6; Hausskn. Monogr. *Epilobium*, 124, 127.—Reichb. Pl. Crit. II, t. 190; Fl. Dan. XI, t. 1815.

473. *Chamaenerion*, tertia species Gesn., 215 v. *Lysimachia siliquosa hirsuta parvo flore* C.B.P. 245 a. *Lysimachia siliquosa hirsuta flore minore* J. Bauh. Hist. II, 906 b. *Epilobium foliis longis dentatis villosis, flore parvo* Hall. Enum. 410. *Epilobium*, *Oenagra* aut ei cognata et eiusdem generis Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 28, t. 19, no. 72 (1770). *Chamaenerion parviflorum* Schreb. Spicil. Fl. Lips. 146 (1771). *Epilobium parviflorum* Schreb. loc. cit., Addenda, fol. K 6; Hausskn. Monogr. *Epilobium*, 66, 69.—Dietr. Fl. Boruss. VIII, t. 572.—*Filius ante patrem mollibus et lanuginosis foliis* Gesn. Tab. Coll. 76 b, in Kyber, Lexic. (1553).

474. *Chamaenerion*, quarta species Gesn., 215 v. *Lysimachia siliquosa hirsuta magno flore* C.B.P. 245 a; J. 88. *Antoniana maior, hirsuta, alba* Gesn. Hort. 247 r. *Antoniana, vel S. Antonii herba foliis hirsutis, sponte circa rivos et fossas nascens* Gesn. Stirp. App. 290 r. *Lysimachia siliquosa hirsuta magno flore* C.B.P. 245 a; S. 44. *Epilobium foliis longis, dentatis, villosis flore magno* Hall. Enum. 410. *Epilobium Filius ante patrem maior* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 31, tt. 20, 21, no. 74 (1770). *Epilobium hirsutum* L. Sp. 347; Hausskn. Monogr. *Epilobium*, 53, 58.—Dietr. Fl. Boruss. VIII, t. 571; Syme, Engl. Bot. IV, t. 497; Dr. 482.—F. 278; *Filii ante patrem species maior* Gesn. Tab. Coll. 77 a, 127 a, in Kyber, Lexic. (1553).

475. *Chamaenerion*, quinta species Gesn., 216 r., ic. 215 v. *Antoniana maxima . . . foliis Rododaphne referens* Gesn. Hort. Germ. 247 r. *Chamaenerion Gesneri* Th. 33; Sch. 56. *Lysimachia Chamaenerion dicta latifolia* C.B.P. 245 b; J. 88; S. 44. *Lysimachia speciosa quibusdam Onagra dicta, siliquosa* J. Bauh. Hist. II, 906 b. *Epilobium spicatum, flore difformi, foliorum nervo eminente, ora leviter serrata* Hall. Enum. 408. *Chamaenerion* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 26, t. 21, no. 70 (1770). *Epilobium angustifolium* L. Sp. 347; Hausskn. Monogr. *Epilobium*, 37, 42. *Chamaenerium angustifolium* (L.) Scop.—Dietr. Fl. Boruss. VIII, t. 570; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, XXII, t. 2256; R. 907; Dr. 482.—*Filius ante patrem maximus* Gesn. Tab. Coll. 76 b in Kyber, Lexic. (1553).

\*476. *Chamaenerion*, sexta et ultima species Gesn., 216 r. *Lysimachia Chamaenerion dicta angustifolia* C.B.P. 245 b; J. 88. *Epilobium spicatum, foliis integerrimis, linearibus, fasciculatis* Hall. Enum. 408. *Chamaenerion aliud* Gesn. Op. ed. Schmidel, II, Hist. Pl. fasc. ii, 28, t. 22, no. 71 (1770). *Epilobium Dodonaei* Vill. Prosp. 45 (1779); Hist. Pl. Dauph. III, 507; Hausskn. Monogr.

*Epilobium*, 45, 48. *Chamaenerium Dodonaei* (Vill.) Wimm. Fl. Schles. ed. 3, 610 (1857).—Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxii, t. 2257.

477. *Conyzoides coerulea* Gesn., 216 r. *Dentelaria quibusdam* Gesn., ic. 216 v. *Dentelaria nostra* Gesn. Hort. Germ. 256 v. *Conyza caerulea acris* C.B.P. 265 a; C. 722; J. 97; S. 48. *Erigeron floribus ex ala foliorum prodeuntibus, flosculis femininis multis imperfectis* Hall. Enum. 724. *Erigeron acer* L. Sp. 863.—Hayne, Arzn. Gewächse, III, t. 30; Dietr. Fl. Boruss. IX, t. 620; R. 265; Dr. 663.—*Tinctorius flos, alterum genus* Trag. Hist. I, 154 (1552). *Conyzoides coerulea* Gesn. Tab. Coll. 70 b. in Kyber Lexic. (1553).

### Liber V.

STIRPIUM DESCRIPTIONIS LIBER QUINTUS QUAE IN ITALIA SIBI VISAS DESCRIBIT. *Argentinae*, 1560.—*Argentorati*, 1563.—vide Gesn. Op. ed. Schmidel, I (1751).

478. *Centaureum maius*, 1 v. (No. 1); Gesn. Op. ed. Schmidel, I, 4; Annot. Diosc. 50 r., maxime. *Centaureum majus folio in lacinias plures diviso* C.B.P. 117 a. *Centaurea Centaurium* L. Sp. 910.—*Centaureum magnum* Matth. Comm. 315 (1554).—vide no. 409 A.

Imported into Germany from Monte Gargano.

479. *Draco sativus*, 1 v. (No. 2); Gesn. Op. ed. Schmidel, I, 4. *Draco herba acetaria* Sylv. 221 v. *Dracunculus hortensis* C.B.P. 98 a; J. 27; S. 14. *Artemisia Dracunculus* L. Sp. 849 (Tarragon).—Kerner, Fig. Pl. Econ. t. 437; Oskamp, Afbeeld. Artseny-Gewass. III, t. 281; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxix, t. 3012; R. 284; Dr. 679; H. 209, 236.—*Draco Ruellius*, De Nat. Stirp. 415, l. 11 (1537). *Dracunculus hortensis* Matth. Comm. 289 (1554).

480. *Cistus foemina*, 2 r. (No. 3); Gesn. Op. ed. Schmidel, I, 4. *Cistus* Annot. Diosc. 20 r. *Cistus foemina folio Salviae* C.B.P. 464 b; C. 747; J. 153. *Cistus salviifolius* L. Sp. 524.—Jacq. Collect. II, t. 8; Sibth. Fl. Graec. v, t. 497; R. 656; Dr. 447.—*Cistus foemina* Matth. Comm. 105 (1554).

481. *Hypocisthis foemina*, 2 r. (No. 4); Gesn. Op. ed. Schmidel, I, 5. *Hypocistis*, Annot. Diosc. 20 r. *Hypocistis sub Cisto* C.B.P. 465 a. *Asarum Hypocystis* L. Sp. 442. *Cytinus Hypocistis* (L.) L. Gen. ed. 6, 576 ('566').—Sibth. Fl. Graec. x, t. 938; Reichb. Ic. Fl. Germ. XI, t. 540; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xxii, t. 2195; R. 249; Dr. 188.—*Hypocistis* Matth. Comm. 105 (1554).

482. *Rhamnus montana*, 3 v. (No. 5); Gesn. Op. ed. Schmidel, I, 5. *Rhamnus folio subrotundo fructu compresso* C.B.P. 477 b; J. 157. *Rhamnus Paliurus* L. Sp. 194. *Paliurus Spina-Christi* Mill. (*P. australis* Gaertn., *P. aculeatus* Lam.).—Duhamel, Traité des Arbres, ed. 2, III, t. 17; Sibth. Fl. Graec. III, t. 240; R. 798; Dr. 410.—*Rhamnus tertius* Matth. Comm. 97 (1554).

483. *Chamaesyce*, 4 r. (No. 6); Gesn. Op. ed. Schmidel, i, 6; Annot. Diosc. 75 r. *Chamaesyce* C.B.P. 293; J. 110. *Euphorbia Chamaesyce* L. Sp. 455. Sibth. Fl. Graec. v, t. 461; Reichb. Ic. Fl. Germ. v, t. 131, fig. 4750; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xx, t. 2052; R. 810; Dr. 387.—*Chamaesyce* Matth. Comm. 544 (1554).

484. *Elichrysus tenuifolia*, 4 r. (No. 7); Gesn. Op. ed. Schmidel, i, 6. *Elichrysus foliis oblongis Stoechadi citrinae similis* C.B.P. 264 a; J. 97. *Stoechas citrina tenuifolia altera sive Italica*, J. Bauh. III, pars 1, 155 (1651). *Gnaphalium italicum* Roth in Roemer u. Usteri, Mag. Bot. iv, no. 10, 19 (1790). *Heli-chrysus italicum* (Roth) G. Don (*H. angustifolium* DC.).—Sibth. Fl. Graec. ix, t. 857 (as '*Gnaphalium Stoechas*'); R. 290; Dr. 667.

485. *Agnus seu Vitis*, 4 v. (No. 8); Gesn. Op. ed. Schmidel, i, 7. *Vitis* Annot. Diosc. 20 v. *Vitis foliis angustioribus cannabis modo dispositis* C.B.P. 475 a; J. 156. *Vitis Agnus-Castus* L. Sp. 638.—Sibth. Fl. Graec. vii, t. 609; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xix, t. 1880; R. 426; Dr. 566.—*Vitis* Matth. Comm. 115 (1554).

486. *Corruda*, 4 v. (No. 9); Gesn. Op. ed. Schmidel, i, 7. *Asparagus foliis acutis* C.B.P. 490 a; J. 160. *Asparagus acutifolius* L. Sp. 314.—*Corruda, sive sylvestris asparagus* Matth. Comm. 251 (1554).—vide no. 85.

487. *Lachryma herba*, 5 r. (No. 10); Gesn. Op. ed. Schmidel, i, 8. *Lithospermum arundinaceum* C.B.P. 258 a; J. 93; S. 47. *Coix Lacryma-Jobi* L. Sp. 972 (*C. Lacryma* L.).—Regn. Bot. III, t. 27; Bot. Mag. t. 2479; R. 54; Dr. 77.

488. *Iasme alba*, 5 v. (No. 11); Gesn. Op. ed. Schmidel, i, 8. *Jasminum vulgatus flore albo* C.B.P. 397 a; C. 743; J. 144; S. 72. *Jasminum officinale* L. Sp. 7.—Duhamel, Traité des Arbres, ed. 2, i, t. 27; Schlecht. Langeth. u. Schenk, Fl. Deutschl. ed. 5, xvi, t. 1535; R. 356; Dr. 527.—*Iasminum* Matth. Comm. 60 (1554).

489. *Rhus seu Byrsodepsicus, vel Rhus obsoniorum*, 6 r. (No. 12); Gesn. Op. ed. Schmidel, i, 9. *Rhus folio Ulmi* C.B.P. 414 a; J. 145. *Rhus coriaria* L. Sp. 265.—Duhamel, Traité des Arbres, ed. 2, II, t. 46; Sibth. Fl. Graec. III, t. 290; R. 850; Dr. 397; Tsch. III, 114; H. 200.—*Rhus* Matth. Comm. 123 (1554).

490. *Zizyphus*, 6 r. (No. 13); Gesn. Op. ed. Schmidel, i, 9. *Jujubae majores oblongae* C.B.P. 446 a; J. 149. *Rhamnus Zizyphus* L. Sp. 194, var.  $\beta$ . *Zizyphus Jujuba* Mill.—*Zizypha* Matth. Comm. 143 (1554).—vide no. 399.

491. *Mespilus aut Mespilus Aronia*, 6 v. (No. 14); Gesn. Op. ed. Schmidel, i, 10. *Mespilus Apii folio laciniato* C.B.P. 453 b; J. 151. *Crataegus Azarolus* L. Sp. 477.—Plenck, Ic. Pl. Med. iv, t. 390; Reichb. Ic. Fl. Germ. xxv, t. 106; R. 951; Dr. 274.—*Mespilus prima* Matth. Comm. 138 (1554).

492. *Platanus*, 6 v. (No. 15); Gesn. Op. ed. Schmel, 1, 10; Annot. Diosc. 17 v. *Platanus* C.B.P. 431 a; J. 148. *Platanus orientalis* L. Sp. 999.—Duhamel, *Traité des Arbres*, ed. 2, II, t. 1; Sibth. Fl. Graec. x, t. 945; R. 203; Dr. 271.—*Platanus* Matth. Comm. 86 (1554).

493. *Heliotropium maius*, 7 r. (No. 16); Gesn. Op. ed. Schmel, 1, 10; Annot. Diosc. 76 v. *Heliotropium majus Dioscoridi* C.B.P. 253 a; C. 472; J. 92; S. 46. *Heliotropium europaeum* L. Sp. 130.—Plenck, Ic. Pl. Med. 1, t. 74; Jacq. Fl. Austr. III, t. 207; R. 434; Dr. 560.—*Heliotropium maius* Matth. Comm. 561 (1554).

494. *Ruscus*, 7 r. (No. 17); Gesn. Op. ed. Schmel, 1, 11; Annot. Diosc. 73 r. *Ruscus* C.B.P. 470 a; C. 747; J. 155. *Ruscus aculeatus* L. Sp. 1041.—Reichb. Ic. Fl. Germ. x, t. 437, fig. 968; Schlecht. *Langeth. u. Schenk, Fl. Deutschl.* ed. 5, IV, t. 291; P.C. 46; L.P. 41; R. 103; Dr. 126.—*Ruscus* Matth. Comm. 523 (1554).

495. *Tamus*, 7 v. (No. 18); Gesn. Op. ed. Schmel, 1, 11. *Bryonia laevis, sive nigra baccifera* C.B.P. 297 b; C. 729; J. 112; S. 56. *Tamus communis* L. Sp. 1028.—Reichb. Ic. Fl. Germ. x, t. 439; Syme, *Engl. Bot.* IX, t. 1508; P.C. 30; L.P. 213; R. 106; Dr. 137.—*Vitis nigra* Matth. Comm. 555 (1554).

496. *Gerrus*, 7 v. (No. 19); Gesn. Op. ed. Schmel, 1, 12; Annot. Diosc. 21 v. *Quercus calice echinato glande majore* C.B.P. 420 b; J. 146. *Quercus Cerris* L. Sp. 997.—Duhamel, *Traité des Arbres*, ed. 2, VII, t. 57; Hayne, *Arzn. Gewächse*, XII, t. 48; R. 186; Dr. 165.

\*497. *Marum* 8 r. (No. 20); Annot. Diosc. 53 r. Possibly *Origanum hirtum* Link.

498. *Medica*, 8 v. (No. 21); Gesn. Op. ed. Schmel, 1, 13. *Medica* Annot. Diosc. 46 r. *Medica vera* Gesn. Hort. 267 r. *Trifolium siliqua cornuta, sive Medica* C.B.P. 330 a; C. 735; J. 123; S. 61. *Medicago sativa* L. Sp. 778 (Lucerne).—Reichb. Ic. Fl. Germ. XXII, t. 60; Schlecht. *Langeth. u. Schenk, Fl. Deutschl.* ed. 5, XXIII, t. 2334; R. 988; Dr. 314; H. 2, 73.

499. *Calaminthe montana maior, seu serrata*, 8 v. (No. 22); Gesn. Op. ed. Schmel, 1, 13. *Calamintha pulegii odore, sive Nepeta* C.B.P. 228 a; J. 81. *Calamintha nepetoides* Jord. Obs. IV, 16, t. 2, fig. B (1846). *Satureja Nepeta* var. *nepetoides* (Jord.) Béguinot.—*S. Calamintha* var. *nepetoides* (Jord.) Briq. *S. Calamintha* subsp. *nepetoides* (Jord.) Braun-Bl.—Cusin, *Herb. Fl. France*, XVIII, t. 53; Coste, *Fl. France*, III, 96, fig. 2877; R. 413 (*C. Nepeta*); Dr. 578.—*Calamintha altera* Matth. Comm. 341 (1554).

The general description and the strong smell and taste of Pennyroyal indicate *Satureja Nepeta*, while the acutely serrate leaves and lax inflorescences indicate the subspecies *nepetoides*.

500. *Philyra*, 8 v. (No. 23); Gesn. Op. ed. Schmidel, I, 13. *Tilia* Annot. Diosc. 19 v. *Phillyrea folio Ligustri* C.B.P. 476 a; J. 157. *Phillyrea media* L. Syst. ed. 10, 847; Sp. ed. 2, 10.—Duhamel, *Traité des Arbres*, ed. 2, II, t. 27; Coste, *Fl. France*, II, 543, fig. 2464; R. 359; Dr. 525.—*Phillyrea* Matth. Comm. 103, ic. 104 (1554).

\*501. *Philyrina*, 9 r. (No. 24); Gesn. Op. ed. Schmidel, I, 14. *Phillyrea latifolia* L. Sp. 8.—Sibth. *Fl. Graec.* I, t. 2; Coste, *Fl. France*, II, 543, fig. 2465; R. 359; Dr. 525.

502. *Ladon sive Lada*, 9 r. (No. 25); Gesn. Op. ed. Schmidel, I, 14; Annot. Diosc. 20 r., partim. *Cistus ladanifera Monspeliensium* C.B.P. 467 a. *Cistus monspeliensis* L. Sp. 524—Sibth. *Fl. Graec.* v, t. 493; R. 655.—*Ledum* Matth. Comm. 106 (1554).

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#### SUMMARY OF CONTENTS.

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The most important of the early German herbals, on account of the excellent descriptions which it contains. Valerius Cordus may be regarded as the real founder of modern phytography. The herbal includes various exotic drugs and timbers, in addition to many medicinal plants wild or cultivated in Germany and Italy.

##### 2. *Life of Valerius Cordus* (pp. 3-5).

Son of Euricius Cordus, author of the 'Botanologicon' (1534). Born 1515, died 1544. Compiled a pharmacopoeia adopted by the city of Nuremberg, and wrote a commentary on Dioscorides, 'Materia Medica'. Travelled in Germany and Italy, searching for medicinal plants, and described many of them in his 'Historia.'

##### 3. *Publication of the Herbal* (pp. 5-8).

Published posthumously, edited by Gesner. Books I-IV appeared in 1561, along with the commentary on Dioscorides and other works. Book V, containing 25 descriptions of Italian plants, was issued separately in 1560 and 1563 and reprinted in 1751 in Schmidel's edition of Gesner's 'Opera'.

##### 4. *Previous identifications of the plants described and figured* (pp. 8-10).

Gesner, as editor, had to identify the plants described by Cordus, in order to supply figures from Bock's herbal (1552) and other sources. Out of about

270 figures given, 220 were correctly attached to descriptions in the 'Historia' and over 40 (16 per cent.) represent species different from those described. This has led to many mistakes by subsequent authors, who failed to realize that the figures were added by Gesner and hence did not necessarily correspond with the descriptions. Dierbach named about 265 plants from the 'Historia', about 33 (12 per cent.) of his identifications being incorrect. August Schulz (1916) named 59 plants for which localities in middle Germany are cited in the 'Historia', misidentifying only four (7 per cent.).

5. *Systematic conspectus of the plants described and figured* (pp. 11-18).

Previous records are indicated by means of abbreviations.

6. *Enumeration of the plants described and figured* (pp. 19-104).

The methods employed in identifying the descriptions and figures are indicated. Full synonymy is not given, but only such references as seem necessary or desirable.

7. *Index of accepted scientific names of the plants described and figured* (pp. 104-109).

Plants mentioned incidentally in the Enumeration are also included.

We desire to thank Sir Arthur W. Hill, K.C.M.G., F.R.S., Director of the Royal Botanic Gardens, Kew, for facilitating the progress of this research in various ways. We are indebted also to Mr. V. S. Summerhayes, for identifications of the numerous Orchids described and figured more or less imperfectly in the 'Historia'; to Mr. C. E. Hubbard, for naming the Grasses; and to Mr. F. Ballard, for his collaboration in the identification of the Ferns.

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The structure and reproduction of *Chaetangium saccatum* (Lamour.) J. Ag.—

II. Female plants\* By MARGARET T. MARTIN, M.Sc., Ph.D., F.L.S.

(With Plate 1 and 38 figures in the text)

[Read 5 May 1938]

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DURING the last twenty-five years an increasing body of evidence has accumulated to show that the Nemalionales are 'haplobiontic' forms, with only one 'biont' or individual present in the life-history. The term was first proposed by Svedelius in 1915 for the type of life-cycle shown by *Scinaia furcellata*, where reduction division takes place immediately after fertilization and the asexual spores are accessory monospores. Since then, evidence of a similar life-cycle has been furnished for *Nemalion multifidum* by Kylin (1916) and Cleland (1919), for *Batrachospermum moniliforme* by Kylin (1917), and in more recent years by Svedelius for *Bonnemaisonia asparagoides* and *Asparagopsis armata* (1933). It seems probable, in the words of Svedelius, that 'the order Nemalionales will very likely prove to be a haplobiontic order of the Rhodophyceae'. In fact, so far the only suggestion of a life-history differing from the *Scinaia* type is that seen in *Liagora tetrasporifera* (Børgesen, 1927), where the carpospores which terminate the gonimoblast filaments show cruciate divisions; unfortunately no cytological details are available for this species, so it is not yet known whether reduction division has been postponed from its usual position immediately after fertilization and takes place here at 'tetraspore' formation. If so, *Liagora tetrasporifera*, although still 'haplobiontic' according to Svedelius's terminology (1931), would form an important link between the rest of the Nemalionales and the diplobiontic Florideae.

Although there is such uniformity in life-history, it is clear that there are forms amongst the Nemalionales which differ considerably in complexity. The 'higher' genera, placed in the Bonnemaisoniaceae and Chaetangiaceae,

\* Part I.—The structure and reproduction of *Chaetangium saccatum*: vegetative structure and male plants. *Proc. Linn. Soc. Lond.* 148th Session, pp. 165–81, 1936.



show an increase in vegetative differentiation and an elaboration of the gonimoblast and cystocarp; they are of especial interest in revealing the degree of specialization reached by the haplobiontic Florideae, and, if we accept Svedelius's view of an evolutionary progression from haplo- to diplo-biontic types, they may well give indications of the course which was followed in that progression. Owing to the work of Svedelius on *Bonnemaisonia asparagoides* and *Asparagopsis armata*, the Bonnemaisoniaceae are becoming better known; the Chaetangiaceae, however, contains a number of complex types and the only one so far examined in any detail is *Scinaia*. Of *Chaetangium* itself practically nothing is known. Schmitz and Hauptfleisch (in Engler and Prantl, 1897) give a short account of the genus, but there exists no description of the structure and reproduction, and asexual spores and antheridia have up till now not been seen. This investigation of *Chaetangium saccatum* was therefore undertaken at the suggestion of Miss E. L. Stephens, who has collected and sent me material from the shores of the Cape Peninsula. An account of the first part of the work, dealing with the vegetative structure and the male plants has already been published (Martin, 1936); the present paper deals with the structure and development of the female plants, and includes some discussion as to the probable relationships of the genus.

A brief account of our somewhat scanty knowledge of the Chaetangiaceae would seem to be in place here. Schmitz and Hauptfleisch (1897) divide the family into two subgroups: the Scinaieae, characterized by a cystocarp with a definite wall and a basally placed gonimoblast from which carpospore-bearing filaments radiate; and the Chaetangieae, with the gonimoblast lining the cystocarpic cavity and producing carpospores all over its inner surface. In the first group are included *Scinaia*, whose life-history has since been elucidated by Svedelius (1915), and *Gloiophloea*, similar in its cystocarp, but differing in the small-celled surface-layer of the thallus; to these Setchell (1914) adds a third genus *Pseudoscinaia*, which resembles *Scinaia* in vegetative characters, but differs in having branches of its gonimoblast which creep round the base of the cystocarpic cavity. Antheridia and asexual spores (monospores) have only been seen in *Scinaia*, where they are both superficial.

The Chaetangieae contains four genera: *Galaxaura*, *Actinotrichia*, and *Chaetangium* in the 1897 account, to which was added later (Svedelius, 1911) *Whidbeyella*, a genus founded by Setchell and Gardner (1903) for a single specimen with cystocarps of the *Galaxaura* type, which was found in drift on the coast of Washington, U.S.A. Of these, *Galaxaura* and *Actinotrichia* are generally calcified, and are very similar in vegetative construction; *Actinotrichia* has a central gonimoblast which encroaches only slightly on the basal part of the cystocarp, i.e. rather nearer to the *Scinaia* type. Weber van Bosse (1921), however, considers that the great similarity in vegetative features justifies the inclusion of this genus near to *Galaxaura*. *Whidbeyella* and *Chaetangium* are not calcified; the single specimen of *Whidbeyella* has a flat branched frond, with immersed cystocarps of the *Galaxaura* type with a very definite 'pedicel'

which Setchell considers has been formed from the lower cells of the procarpial branch. The different species of *Chaetangium* vary considerably in habit and structure, the fronds either being flattened or hollow and inflated; the cystocarps as far as is known resemble those of *Galaxaura*, but are often lobed, and are apparently lined by a layer producing tufts of carpospores.

None of these last four genera is known in any detail, and in none has the life-history been followed. *Galaxaura* has been treated by several workers, but mainly from a systematic point of view; its vegetative construction is well known, but its reproductive organs have never been examined in detail. This genus and *Actinotrichia* bear tetraspores, always formed on different plants from the sexual organs\*, and with tetrahedral or cruciate, but often irregular divisions. Antheridia occur in both these genera in spherical conceptacles, superficially very like the cystocarps; they are lined with tufts of branching filaments which produce the spermatia. Neither asexual spores nor antheridia have up till now been seen in *Whidbeyella* or *Chaetangium*.

Practically nothing is known of the carpogonial branches or their development in this subfamily. The only figure is that of Schmitz (in Engler and Prantl, 1897) of the carpogonial branch in *Galaxaura adriatica*, which is three-celled, and shows outgrowths from each of the two lower cells. It is assumed that these outgrowths give rise to the 'wall'; the origin or development of the gonimoblastic lining is completely unknown. Schmitz and Hauptfleisch state that the paraphyses which at first fill the developing conceptacle arise from the wall and are replaced later by carpospore-bearing filaments derived from the gonimoblast.

It is evident, then, that the Chaetangiaceae are as yet little known, and *Scinaia* is the only member which has been described in any detail. Other genera would seem to have an especial interest in view of the fact that some of them, e.g. *Galaxaura*, bear tetraspores, and, moreover, these are borne on separate plants quite distinct from the sexual individuals. Until the cytology of these genera can be worked out and their life-histories elucidated, their systematic position must rest in abeyance; they are obviously of great interest, and may have bearings upon our conception of the Nemalionales as a group.

*Material and distribution.*—The account of the distribution of *Chaetangium saccatum* given in the previous paper (Martin, 1936) was based upon published data and upon information sent to me by Miss E. L. Stephens. Since then, however, I have had the opportunity of visiting South Africa and of examining the plant in situ, and should like to add a few remarks.

*C. saccatum* is endemic to South Africa and is most abundant on the west coast of the Cape Province, where it has been recorded in a number of localities from Port Nolloth southwards. On most of these shores there is a definite

\* Harvey-Gibson and Knight (1913) observed tetrasporangia on sexual plants of *G. oblongata*, but Bergesen (1927) has never seen these; they probably represent an irregularity such as is commonly met with in the higher Florideae.

*Chaetangium* zone in the upper part of the tidal region below a belt of *Porphyra capensis*; in this zone the two species *C. ornatum* and *C. saccatum* occur, the latter species at a rather higher level on the shore. Dr. Isaac (1937) has found that at Lambert's Bay *C. saccatum* dominates this zone, but on passing southwards it becomes less abundant, and towards the south end of the Cape Peninsula is replaced to a large extent by *C. ornatum*. This decrease in numbers of *C. saccatum* on passing southwards is probably due to the increase in temperature. The west coast of the Cape is subject to the influence of cold currents from the south, and it seems that *C. saccatum*, which is found on the western side, is characteristic of colder waters; on the eastern coast of the Cape Peninsula, where warmer currents sweep round from the Indian Ocean, *C. ornatum* is abundant, but plants of *C. saccatum* are scanty and generally stunted (Delf and Michell, 1921). Isaac, however, has found fruiting specimens at Kalk Bay on the eastern side, and a few plants were found by Dr. Papenfuss at Cape Agulhas, considerably further east. It is interesting to note the much smaller size of these specimens from the warmer east side; Isaac (1938) has found plants on the west coast as much as 10 cm. long, while those from the east rarely exceed 1.6 cm., one mature female plant fruiting when only 0.32 cm. in length.

In general, *C. saccatum* is especially abundant on a granitic substratum, though it is also frequent on the tilted slate rocks of Table Bay; it is rarely found in pools, but generally on bare rock surfaces, where it is subject to considerable desiccation during periods of exposure. Occasionally, overlying fronds of *C. ornatum* may furnish some protection, but it is common to find the plants extremely hard and brittle during the exposure period of spring-tides.

In the previous paper an account was given of the vegetative structure of the thallus; male plants were described for the first time, and the development of the antheridia and spermatia followed. The elucidation of developmental stages in the female plants has, however, presented great difficulty. Owing to its tough gelatinous nature, the material is extremely difficult to handle, yet the very narrow filaments composing the thallus make thin microtomed sections a necessity. The small size of the nuclei, too, has made it impossible, except in a few places, to obtain any nuclear differentiation, and vegetative divisions have never been seen. In following the development of the gonimoblast and cystocarp it has therefore been necessary to rely almost entirely on the origin and position of the component cells; although, owing to its large size, the gonimoblast becomes very complicated, it is possible after prolonged search to find pit connexions between related cells. By these means, a more or less connected developmental story has been made out. For complete proof it is, of course, necessary to find good nuclear stages and to count chromosomes, but it is thought that the picture presented here is substantially a true one, and certainly the nuclear evidence which is available entirely supports the views put forward.

## DEVELOPMENT AND STRUCTURE OF THE CARPOGONIAL BRANCH.

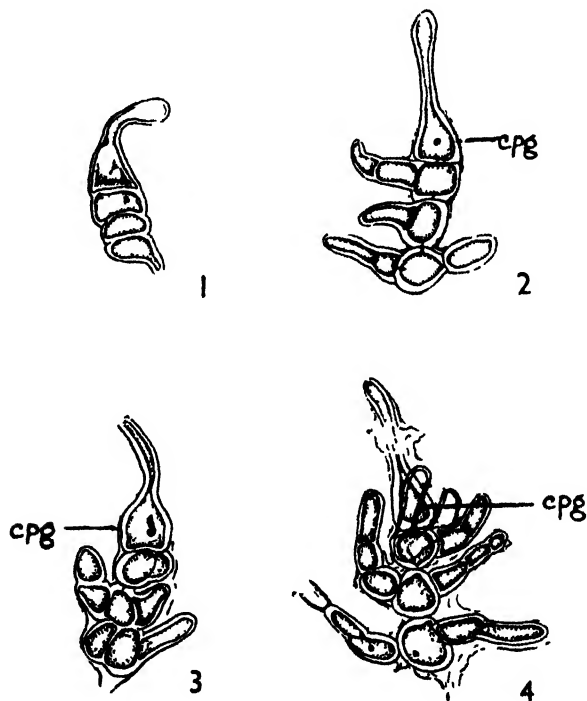
Mature female plants are easily recognized by the presence over most of their surface of scattered cystocarpic lumps, which are visible especially by transmitted light as opaque spots about the size of a pin's head (Plate 1, fig. 1); the cystocarp projects into the central cavity of the plant, and consists of a hollow 'conceptacle' opening to the exterior by a small ostiole, which can be seen on examination of the surface with a lens. Ripe cystocarps apparently occur at all seasons of the year, for collections were made once or more during each month and they were abundant in all the samples examined.

Young carpogonial branches can be recognized in the apical growing region; at a distance of 1 cm. from the apex many of them are at quite an advanced stage of development, and at about 2 cm. the cystocarps and carpospores are mature. It seems probable, however, that many carpogonial branches fail to achieve fertilization and therefore do not develop beyond an early stage, for some in quite a young condition are often found amongst ripening cystocarps.

The young carpogonial branch arises laterally from one of the cortical filaments and is deep-seated, occurring near the inner boundary of the compact cortical zone. The branch when first distinguishable consists of a row of four cells, which are wide tangentially and short in a radial direction (fig. 1), their width and homogeneous contents distinguishing them from the cells of surrounding vegetative filaments. At this stage a very small nucleus can be seen in each cell, and the terminal cell is beginning to elongate to form the trichogyne. As growth takes place, the branch becomes stretched out, so that the three lower cells are rounded, their walls thicker, and pit connexions are very evident between them and also between the uppermost of them and the carpogonium (fig. 2). During this time the tip of the carpogonium elongates considerably to form the trichogyne, and from each of the three lower cells are cut off several small lateral branches of from one to three cells each (figs. 2, 3, & 4). Thus a carpogonial branch is formed consisting of a number of cells, such as is described by Schmitz and Hauptfleisch (in Engler & Prantl, 1897) as:—'Carpogonäste in Gestalt sehr kleiner, gedrungenen, kleinzelliger Zweigbüschelchen auf der Innengrenze der Aussenrinde ausgebildet.' The only figure given by these authors is of *Galaxaura adriatica* where the branch is three-celled, but very similar; the carpogonium has grown out into a long straight trichogyne and the two lower cells have both given rise to several branched filaments of three to five cells each.

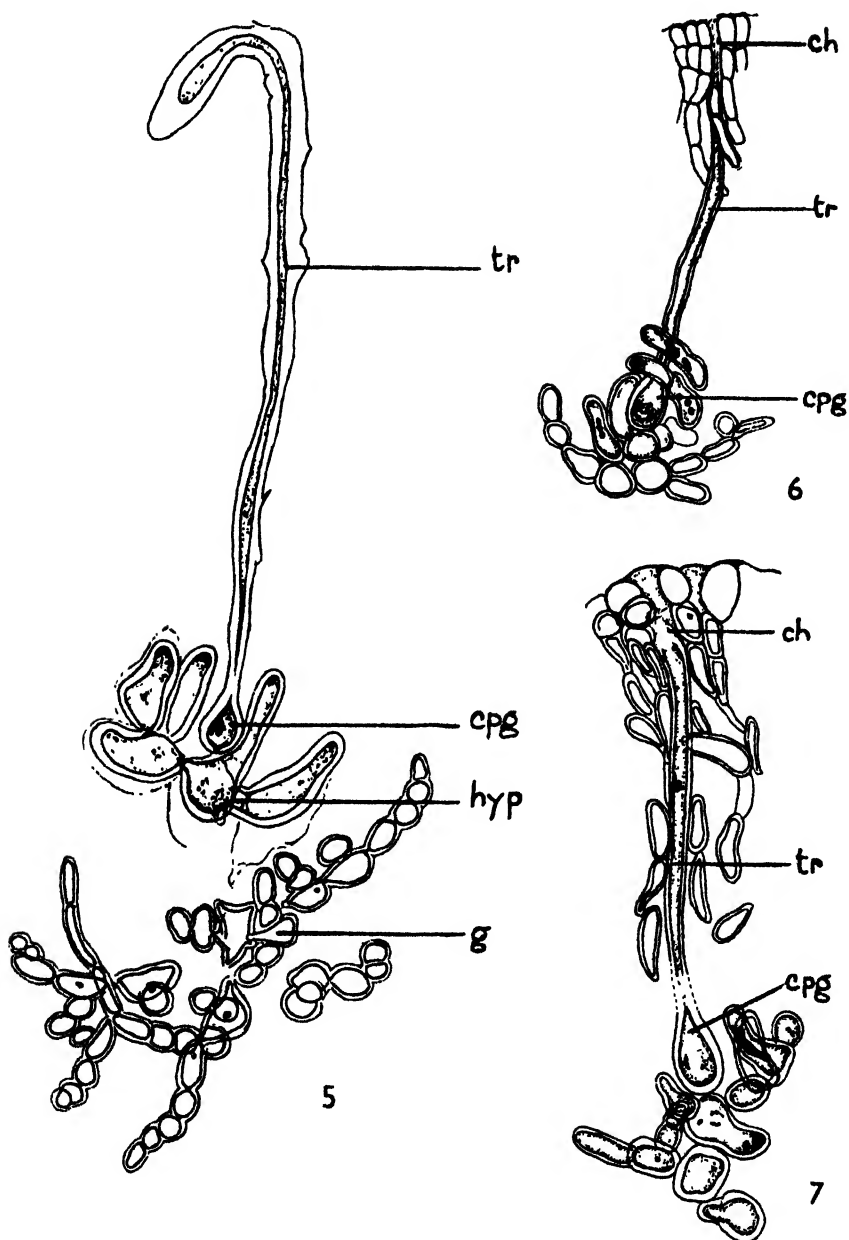
The cells cut off from the lower part of the carpogonial branch are undoubtedly comparable with the 'sterile cells' formed before fertilization in other members of the Nemalionales. These may have a purely nutritive function as in *Bonnemaisonia asparagoides* (Svedelius, 1933) and *Naccaria Wigghii* (Kyllin, 1928). In *Scinaia*, however (Svedelius, 1915), three large cells are cut off from the hypogynous cell and together with it form a 'hypogynous disc' with ultimately a nutritive function, while chains of filaments are cut off from the lowest cell of the branch and these later produce the firm cystocarpic wall.

In *Chaetangium* the fusion of male and female nuclei has not been seen, and it has therefore not been possible to fix the stage at which fertilization occurs. The 'sterile cells', however, develop in a region close behind the apex of the thallus where the carpogonial branch is very young, and before the trichogyne has attained its full length, and there seems no doubt that they are formed before fertilization and are comparable with the 'sterile filaments' in other genera. Their destination and function will be seen at a later stage.



FIGS. 1-4.—Young carpogonial branches seen in vertical sections through the thallus. 1, very young four-celled stage; 2, 3, & 4, showing elongation of trichogyne and development of sterile cells from lower three cells of branch. *cpg*—carpogonium.  $\times 1200$ .

The carpogonium becomes pear-shaped, but always remains small. Its lower part is filled with an irregular deeply-staining mass, and in some cases a nucleus has been distinguished, but there, as in the vegetative cells, the nucleus is extremely small, and it has not been possible to obtain any further differentiation of it. The trichogyne elongates considerably and grows out towards the surface; it generally pursues a devious course between the closely packed cortical filaments. Owing to this curvature of the trichogyne, it is not often possible to see the whole of its length in section; whole trichogynes have,



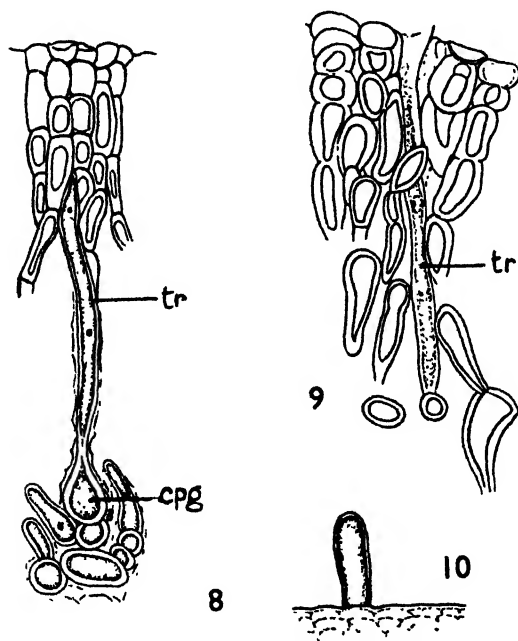
FIGS. 5-7.—Carpogonial branches. 5, whole carpogonial branch dissected from thallus,  $\times 1200$ . 6 & 7, carpogonial branches as seen in vertical sections. 6, shows trichogyne leading into channel between the surface-cells,  $\times 800$ . 7, shows nucleus in trichogyne,  $\times 1200$ . tr, trichogyne; cp, carpogonium; hyp, hypogynous cell; g, gonimoblast cells; ch, channel.

however, been isolated from teased and crushed material (fig. 5) and it is generally possible to recognize pieces of the trichogyne by means of the very thick and rather ragged mucilaginous wall. The tip is rounded and swollen, and in fresh material it can be seen projecting for a short distance from the surface of the thallus (fig. 10); the other figures (6, 7, & 9) are drawn from fixed and embedded material and the tips of the trichogynes have generally been broken off. In figs. 6 and 7 there can be seen between the epidermal cells a narrow channel through which the trichogyne passes. Since the carpogonial branch is so deep-seated, the trichogyne often reaches a considerable length, and may be as much as ten times the length of the carpogonium; in *Scinaia* the carpogonium is borne much nearer the surface, and the trichogyne therefore is only about half this length. The extremely devious course pursued by the trichogyne in *Chaetangium* might well be thought to be due to the difficulty of penetrating between the very compact cortical filaments, and it may be compared with that in *Polyides rotundus* (Kylin, 1923) which in penetrating through the dense cortex often becomes looped round into a circle; in *Bonnemaisonia asparagoides*, however (Svedelius, 1933), where the trichogyne projects freely from the surface, it is often as long as that in *Chaetangium*, and is characteristically coiled.

In about six or eight of the trichogynes examined (out of some thirty or forty) there is a small deeply staining body present (fig. 7). Its small size and lack of differentiation at first suggested that this was a degenerating trichogyne nucleus rather than a male nucleus on its passage down the trichogyne. Such a trichogyne nucleus has been seen in many of the higher Florideae, but in the Nemalionales it does not seem to be of constant occurrence. In those genera where it has been recorded, however, it does not generally survive in the upper part of the trichogyne; it is true that Svedelius figures it in *Scinaia* near the tip, but in *Asparagopsis armata* it is seen in a degenerating condition near the base, while in *Nemalion multifidum* Cleland (1919) finds that it is very small and never survives long enough even to reach the trichogyne. In the light of these genera, it seems possible that the deeply staining body in the upper part of the trichogyne in *Chaetangium* is not a degenerating trichogyne nucleus, but a male nucleus on its way down the trichogyne. This would seem to be likely at least in some cases, for several trichogynes have been found in which two nuclei are present (one of these is shown in fig. 8). Here, one of the two must be a male nucleus; the other may still be interpreted as a trichogyne nucleus, but is more likely a second male nucleus such as is often seen in other members of the group. Fig. 9 shows the only trichogyne found in which there is a nucleus with any differentiation; this, however, is very suggestive, as its condition undoubtedly recalls that of the male nucleus figured in the ripe spermatium. On the whole, therefore, the evidence indicates that a trichogyne nucleus may be present at an early stage, and that the mature trichogyne sometimes shows a male nucleus on its passage towards the carpogonium.

In the absence of any direct evidence from the fusion of male and female nuclei, the carpogonial branch is assumed to be ready for fertilization at the

stage shown in figs. 5-10 when the trichogyne has reached the surface of the thallus, has a thick gelatinous wall and rounded tip, and often contains one or more nuclei. At this stage there is already a thickening of the wall at the base of the trichogyne, so that its contents are considerably constricted at that point; Svedelius's figures of *Scinaia* (1915) and *Asparagopsis armata* (1933), however, show a similar constriction before the male nucleus has passed down the trichogyne into the carpogonium.



FIGS. 8-10.—Parts of carpogonial branches as seen in vertical section through the thallus,  $\times 1200$ . 8, shows two nuclei in the trichogyne; 9, shows large (probably male) nucleus in the trichogyne. For explanation see text. 10 (from fresh material), shows tip of trichogyne projecting from thallus. *tr*, trichogyne; *cpg*, carpogonium.

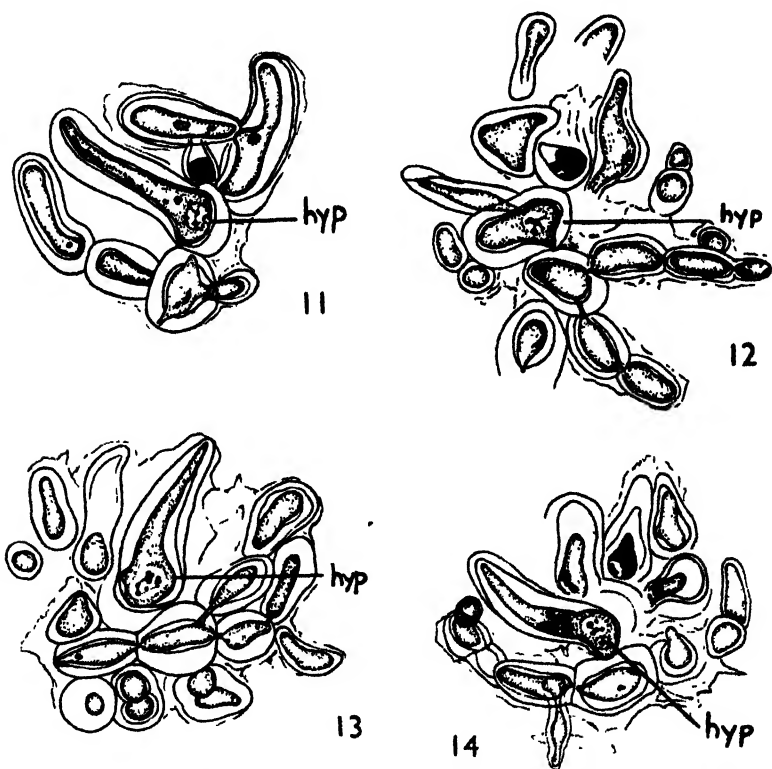
No convincing evidence is forthcoming in *Chaetangium* for the fusion of male and female nuclei. At a later stage, however, the trichogyne shrivels, and its shrunk remains can be seen attached to the base of the carpogonium. The carpogonium itself always remains small; it can be seen for some time attached by a pit connexion to the hypogynous cell, and with shrunk deeply-staining contents, but in later stages can no longer be distinguished. In view of the well-developed trichogyne with rounded gelatinous tip and the presence in it of one or more nuclei, it is considered probable that a normal fertilization does occur; but, if so, the products must migrate from the carpogonium into the hypogynous cell below, for the carpogonium obviously plays no further part in



development. As will be seen later, there is considerable evidence from the phenomena observed in the hypogynous cell that a fusion nucleus has passed into this from the carpogonium.

#### ORIGIN AND DEVELOPMENT OF THE GONIMOBLAST.

In branches with a well-developed carpogonium and trichogyne, further outgrowth has taken place from the lower cells of the branch. At an early stage the second or hypogynous cell had already cut off a number of one- (or rarely two-) celled branches; the cells of these increase considerably in size,



FIGS. 11-14.—Carpogonial branches after degeneration of the trichogyne, showing hypogynous cells each with 'fusion nucleus'. For explanation, see text. *hyp*, hypogynous cell.  $\times 1200$ .

and together with the original hypogynous cell constitute a 'hypogynous disc', comparable with the four-celled disc present in *Scinaia*. There are generally five or six of these cells, which elongate and curve upwards around the carpogonium. Their walls become very thick and gelatinous, and they often show darkly staining contents, especially at the tips; it is thought that some of this is due to ragged plastids, and there are certainly several nuclei

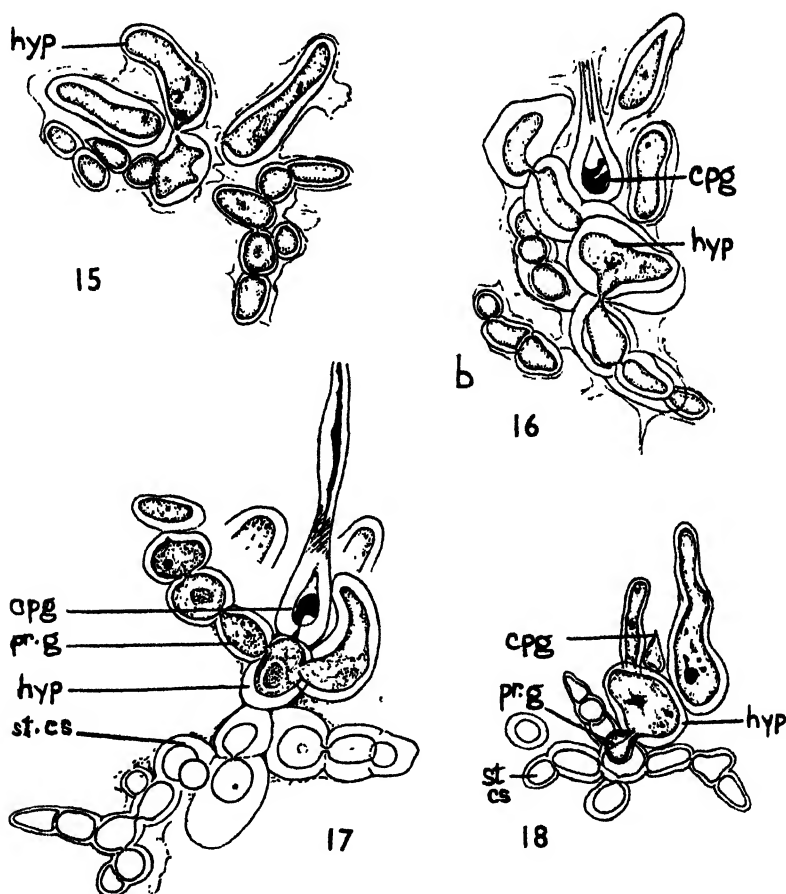
present in the older stages. These hypogynous cells are the most conspicuous feature of the branch at this stage of its development (fig. 5). As in *Scinaia* one of them (the original hypogynous cell) remains in pit connexion with the carpogonium, and the contents of this cell show a striking difference from those of its neighbours. In a great number of carpogonial branches examined, this hypogynous cell has a very large nucleus, which is often differentiated into a number of deeply staining granules; such stages are illustrated in figs. 11-14. Fig. 11 shows a stage which is fairly common; the large nucleus has a central clear region around which a number (seven to ten) of deeply-staining granules are arranged. Fig. 12 shows a condition very suggestive of a synzeysis stage, with a tangled thread contracted at one side of the nucleus. In figs. 13 & 14 there are a number (8-10) of rounded deeply staining bodies, probably chromosomes; owing to the extremely small size of the nuclei it is not possible to say with certainty that these are bivalents, though the appearance is that of a diakinesis stage. It is interesting to note the great similarity between this and the comparable stage figured by Svedelius for *Bonnemaisonia asparagoides* (1933, fig. 47 c), although a larger number of chromosomes is present in that genus.

Since another much smaller nucleus is sometimes present in the hypogynous cell (fig. 14) it is thought highly probable that the larger one is the 'fusion nucleus', which has migrated into the hypogynous cell from the carpogonium. Its size and differentiation suggest this, and the stages figured are very suggestive of a fusion nucleus preparing for meiosis. This is supported by the fact that in several cases at least three nuclei can be seen lying freely in the hypogynous cell (fig. 15); these still show the same deeply staining granules, and are thought to be three of the nuclei of the meiotic tetrad.

If it is true that the fusion nucleus has migrated from the carpogonium to the hypogynous cell, one would expect to find some evidence of a widened pit connexion between the two. This has been sought, and has been found in one or two cases; and in several branches there is a darkly staining plug between the carpogonium and the hypogynous cell (fig. 17), very similar to that figured by Svedelius for *Scinaia* and *Asparagopsis armata*.

Meanwhile, from the third cell of the carpogonial branch (the cell below the hypogynous cell) a number of filaments have grown out. These were visible at an early stage, before fertilization (fig. 4), but by this time they have increased in number, and now consist of four or five cells each. These short chains of cells can be recognized by their regular shape, their lightly staining contents, and very small nuclei. They are apparently 'sterile filaments', and it was thought for some time that they represented the initiation of 'wall filaments' comparable to those in *Scinaia*, where very similar chains of cells grow out from the third cell of the branch and cohere laterally to form a shell-like covering to the cystocarp. Examination of mature cystocarps of *Chaetangium*, however, shows quite clearly that no sterile 'wall' is present; the whole covering of the cystocarpic cavity is composed of a densely interwoven mass of gonimoblast filaments, which undoubtedly give rise to the carpospores.

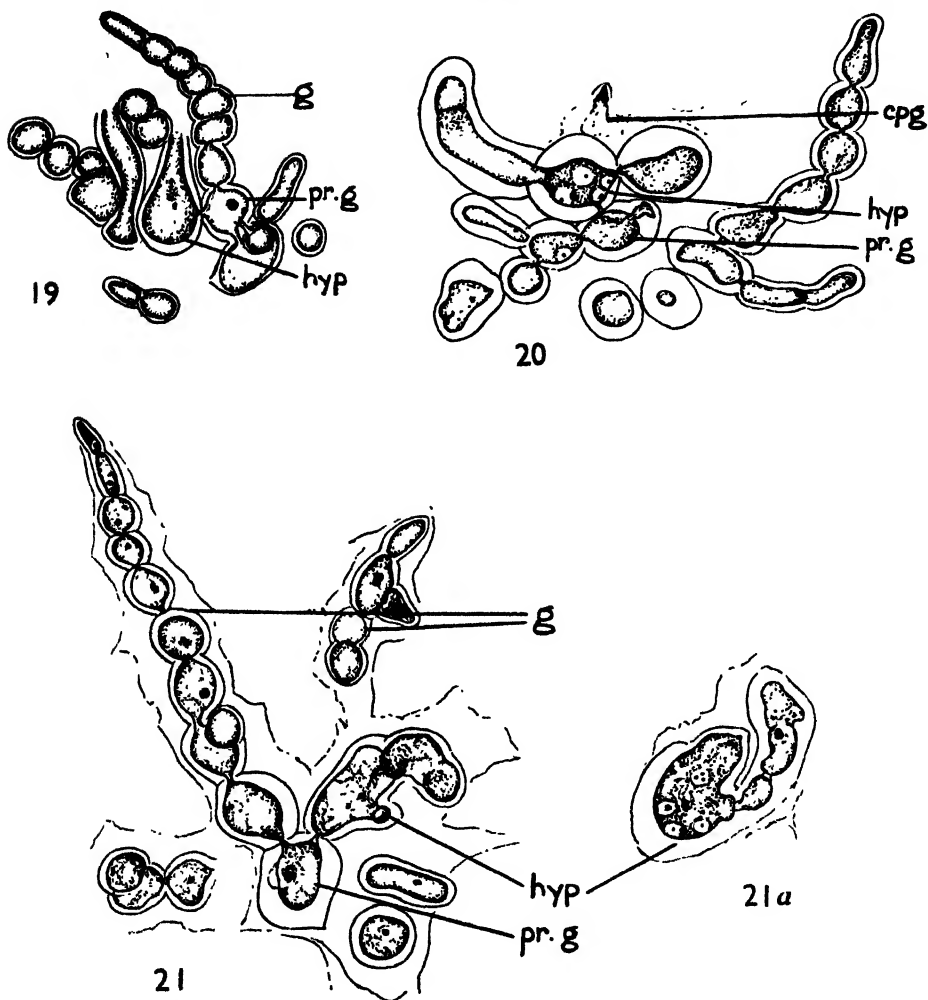
It seems, then, that these 'sterile filaments' develop no further, but that they are entirely replaced by the developing gonimoblast. They are probably nutritive in function, and evidence has been sought for the passage back of their contents to the cells of the carpogonial branch; such, however, is very



FIGS. 15-18.—Parts of carpogonial branches after fertilization,  $\times 1200$ , showing:—  
15, hypogynous cell with several nuclei, probably those of the meiotic tetrad; 16, origin of filament from hypogynous cell (probably gonimoblast); 17, origin of gonimoblast from hypogynous cell, as a short chain of four cells on left. The sterile cells below are left unshaded; 18, origin of primary gonimoblast cell from hypogynous cell. *cpg*, carpogonium; *hyp*, hypogynous cell; *pr.g.*, primary gonimoblast cell; *st.cs*, sterile cells.

difficult to find, owing to the early development of the large branching gonimoblast which soon obscures them. In older stages, there is no sign of these 'sterile cells'; sometimes, however, a widening of the pit connexion between

the second and third cells of the branch can be seen, and there seems every likelihood of a passage of nutritive contents from the third cell to the second, by which nourishment of the developing gonimoblast can be effected. That



FIGS. 19-21.—Carpogonial branches showing origin of gonimoblast from hypogynous cell,  $\times 1200$ . 19 & 20, in vertical section. In 20, several nuclei are seen in the hypogynous cell. 21, part of a transverse section through the base of a carpogonial branch, and 21 a, part of the next section showing the same hypogynous cell with nuclei. (For explanation, see text.) *cpg*, carpegonium; *hyp*, hypogynous cell; *pr.g*, primary gonimoblast cell; *g*, gonimoblast filament.

the contents of the 'sterile cells' have contributed to this process seems extremely likely in view of the numerous nuclei present in the large 'fusion cell' found at the base of older cystocarps.

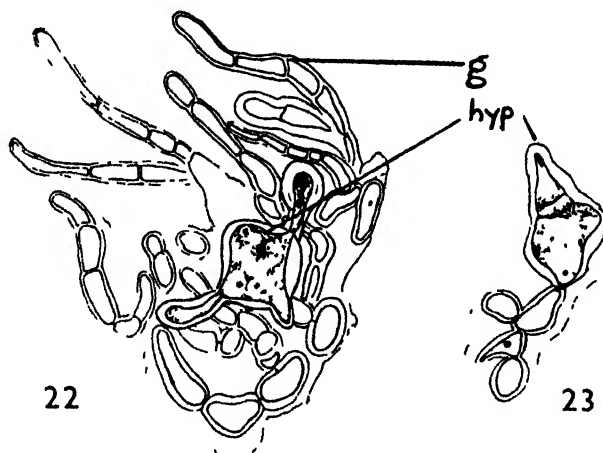
The gonimoblast originates from the hypogynous cell. As has been seen above, there is every reason to suppose that the fusion nucleus has passed from the carpogonium to the hypogynous cell immediately beneath, and has there undergone a reducing division. A small cell then arises from the hypogynous cell, generally from the side of its rounded base; this may be termed the 'primary gonimoblast cell', and it at once produces several chains of gonimoblast filaments. These can be clearly seen in figs. 19 & 20. The condition is therefore similar to that described by Svedelius for *Asparagopsis armata* (1933), where the gonimoblast arises from the hypogynous cell, and the sterile nutritive cells are used up in its development. The carpogonium in *Chaetangium*, as in *Asparagopsis*, clearly plays no further part in development, and after this stage can no longer be distinguished.

Unfortunately it has not been possible to determine with certainty the fate of the nuclei in the hypogynous cell on origin of the gonimoblast. It has been shown above, however, that there is every probability that four nuclei result from a reduction division; and since only one primary gonimoblast cell has ever been seen arising from the hypogynous cell, it seems almost certain that three of them degenerate, while the fourth initiates the young gonimoblast. Figs. 20, 21, & 21 a are very interesting in this connexion. In fig. 20 the primary gonimoblast cell has been budded out from the hypogynous cell and is producing the gonimoblast filaments. In the hypogynous cell, however, four nuclei can still be distinguished; they are but lightly stained in this preparation and no details of their structure can be seen, but it is difficult to resist the interpretation of them as three of the nuclei resulting from meiosis, together with the nucleus of the hypogynous cell itself. In this figure can also be seen the degenerating carpogonium, and a very considerable widening of the pit connexion between the hypogynous cell and the large sterile cell of the 'hypogynous disc' which adjoins it. This can often be seen in older branches, and it is thought that a certain amount of contents passes from these 'disc cells' back into the hypogynous cell. Fig. 21 shows a branch at this stage cut almost transversely. The primary gonimoblast cell has been budded out and has given rise to gonimoblast filaments; its connexion with all these cannot be seen in the plane of section, but it is suggested by the disposition of the mucilage. The hypogynous cell itself has become irregular and lobed; on the right (fig. 21 a) it is shown as seen in the next section, and contains a number of nuclei, the lower three of which are very like those figured in fig. 20 and considered to be the remaining three of the meiotic tetrad. The wide pit connexions with the adjoining disc-cells will also be noticed; these, too, are becoming irregular in shape, and it is likely that some of their contents have passed back into the hypogynous cell.

If the interpretation put forward here is correct, the gonimoblast arises from the hypogynous cell, as in *Asparagopsis armata*, but unlike that genus only one of the reduction nuclei is utilized in its formation, the rest playing no part, and later degenerating. This is the nuclear condition described by Svedelius for *Scinaia furcellata* and *Bonnemaisonia asparagoides*, where, however, the gonimoblast is budded out from the carpogonium itself.

## DEVELOPMENT OF THE CYSTOCARP AND CARPOSPORES.

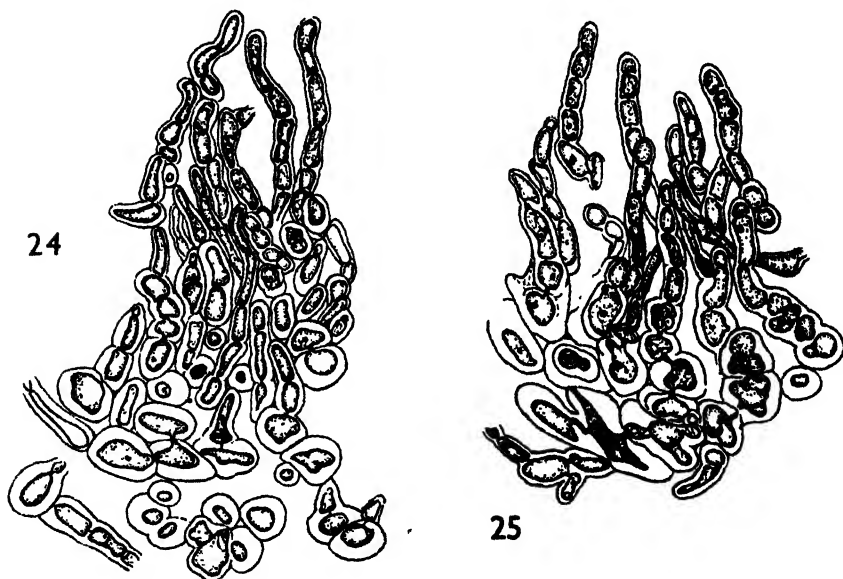
The subsequent development of the gonimoblast is extremely complicated. The chains of gonimoblast cells grow upwards around the remains of the carpogonial branch (fig. 22) and converge again near the surface of the thallus, so that the outline of a flask-shaped cavity is traced. In this figure the enlarged hypogynous cell can be seen; it contains several nuclei, those on the left having all the appearance of those figured previously (figs. 20 & 21 a), and regarded as degenerating nuclei of the meiotic tetrad. The widened pit connexions with the other hypogynous cells can be seen to right and left. On the right (fig. 23) is shown the base of the same hypogynous cell as seen in the next section, and showing quite clearly the pit connexion with the cells of the developing gonimoblast.



FIGS. 22 & 23.—22, part of a vertical section through a developing cystocarp, showing gonimoblast filaments (unshaded) and large hypogynous cells in centre (cf. text); 23, part of the next section showing attachment of the gonimoblast filament to the hypogynous cell. *hyp*, hypogynous cells; *g*, gonimoblast filaments.  $\times 1200$ .

At first the developing cavity is filled with the narrow darkly staining vegetative filaments of the cortical region; later these disappear, and branches arising from the gonimoblast filaments grow in towards the centre of the cavity. Fig. 2, Plate 1, represents a vertical section through a developing cystocarp at this stage. Bordering the cavity can be seen the gonimoblast filaments composed of regular lightly staining cells, from which branches have grown in to the centre; in the upper part the tips of these converge near the surface of the thallus, and their pressure causes separation of the cortical filaments to form an ostiole. At the base of the developing cystocarp can often be seen one or more large cells, with thick walls and deeply staining contents. One of these is generally more conspicuous than the others, and is thought to represent

the cell from which the gonimoblast arose, i.e. the hypogynous cell of the carpo-gonial branch which has now acquired contents from the adjoining sterile cells, and constitutes what may be called a 'fusion cell' (fig. 3, Plate 1). The assimilation of the remaining cells of the hypogynous disc is, however, often not complete, for they can frequently be seen scattered around the base of the developing cystocarp (fig. 4, Plate 1); their shape, thick walls and position suggest that they are the remains of the other hypogynous cells, but they have become detached from the fusion cell by growth and pressure of the inter-weaving gonimoblast filaments. They seem to play no further part in develop-



FIGS. 24 & 25.—Parts of vertical sections through developing cystocarps, showing gonimoblast filaments,  $\times 800$ . 24, young stage; basal layers of rounded cells, and erect 'sterile filaments'. 25, slightly older stage; basal layers showing outgrowths from cells.

ment, and in older cystocarps are no longer to be seen. The fusion cell itself can be distinguished for some time at the base of the cystocarp. It has an extremely thick wall, granular contents, and many nuclei; in older stages, however, it is not generally possible to make out the connexion to it of the massive gonimoblast. The latter has by this time developed plastids and therefore has become to some extent self-supporting; the 'fusion cell' has fulfilled its function, its contents become more scanty, and finally it disappears.

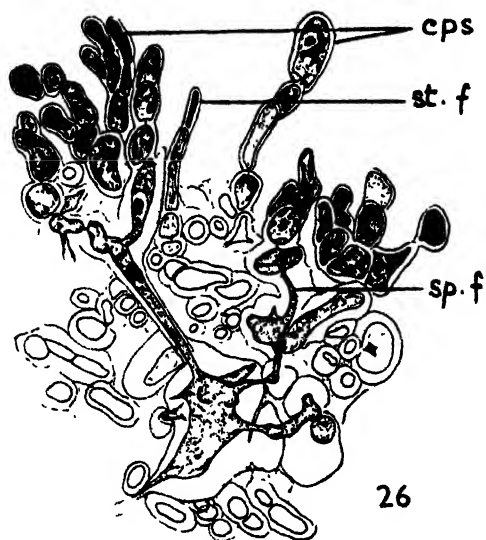
The gonimoblast filaments which surround the cavity are shown in more detail in fig. 24. They consist of chains of cells with thick gelatinous walls,

lightly-staining contents, and small nuclei. From them arise the long unbranched filaments which project into the centre of the cavity. These are very characteristic and easy to recognize, with their regular cells and rounded tips; each cell contains a small nucleus and several plastids, and the gonimoblast can undoubtedly assimilate by means of these filaments. Schmitz and Hauptfleisch (in Engler & Prantl, 1897) call these filaments 'paraphyses' and consider that they arise from the 'wall', a firm structure composed of narrow sterile filaments. They describe a branching gonimoblast which ramifies over the inside of the 'wall', and through which the sterile 'paraphyses' project. Later, according to these authors, the paraphyses die off, and the 'hymenium' or gonimoblastic lining produces richly branching tufts of filaments which bear the carpospores.

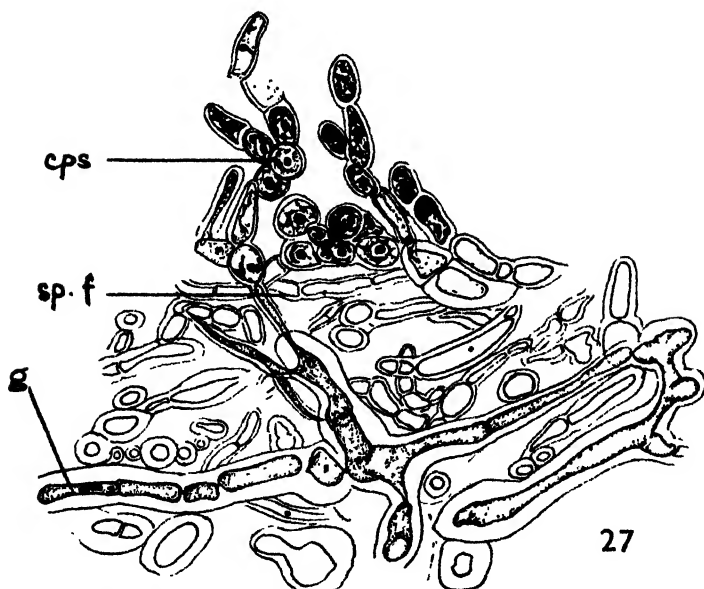
Close inspection of the covering of the cavity shows, however, no such distinction into sterile wall and gonimoblast. All the vertical filaments shown in fig. 24 can be traced downwards to the horizontal branches which bound the cystocarp. The cells are clearly all of one kind, and there is no question of a wall and 'gonimoblastic lining'. The subsequent history of the cystocarp, too, shows that the carpospores are actually produced by development from these so-called 'wall' filaments. As the cystocarp increases in size, the filaments bordering it become stretched out, and those perpendicular to the surface of the cavity separate from each other to some extent (fig. 25). About this time the cells towards the base and those of the horizontal filaments take on an irregularly lobed appearance (fig. 25); they have become multinucleate and a nucleus migrates into each of the lobes. These then grow out into new branches, which wander in all directions amongst the basal layers. In the mature cystocarp these 'lobed cells' have become much enlarged, with very thick walls (fig. 26): they are irregular in shape and are connected by long narrow filaments parallel to the surface of the cavity. A considerable increase in size of the cystocarp has caused much stretching out of the lining, and the large lobed cells are separated by a densely interwoven mass of gonimoblast tissue (fig. 27). Branches have also grown vertically upwards from the 'lobed cells' and can now be followed into the tufts of filaments which line the cavity and produce the carpospores.

Meanwhile, the filaments which project into the developing cavity have become modified. Near the ostiole they undergo little change, and remain as sterile 'paraphyses'. In the rest of the cystocarp, however, they begin to stain more deeply, and their plastids become more evident (fig. 28); in the same figure can be seen a narrowing of the cells four or five cells back from the tip. The upper three or four cells then seem to disappear: they can be seen in various stages of disintegration and must finally be shed, for later the narrow deeply-staining cells terminate the filaments (figs. 29, 30, & 31). Only occasional sterile cells can be seen in the carposporic tufts (fig. 26, *st.f.*), and these are long and narrow, like those in the lower part of the filaments in fig. 28.





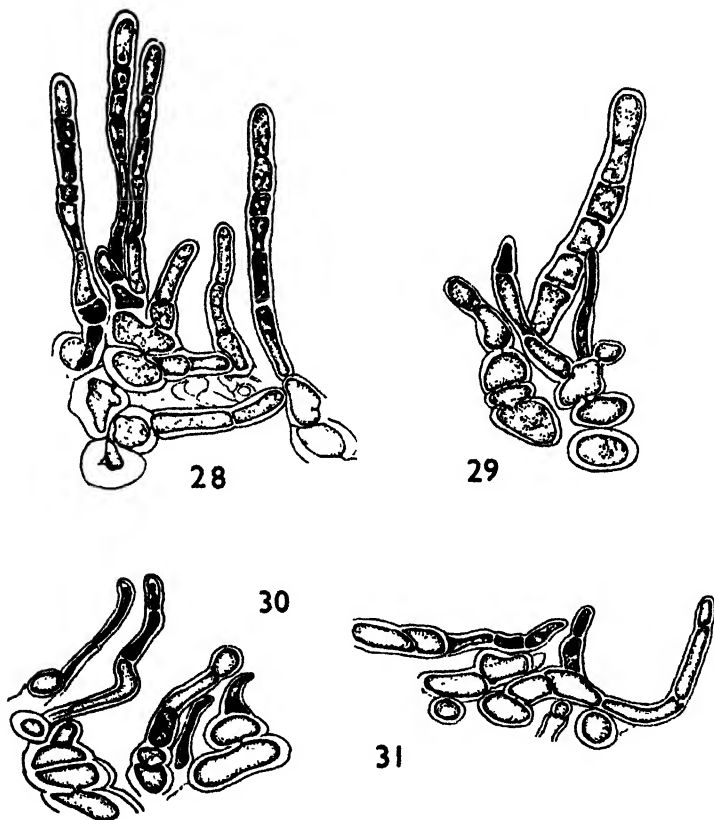
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FIGS. 26 & 27.—Parts of vertical sections through mature cystocarp, showing gonimoblast,  $\times 1200$ . In 27, the horizontal gonimoblast filaments can be seen; also vertical 'sporogenous filaments' arising from them and producing carpospores. In 26 the 'sporogenous filaments' can be traced to a large lobed cell of the gonimoblast (see text). (In both these figures, one part of the gonimoblast and sporogenous filaments is drawn in detail; the rest, although exactly similar, is left unshaded for the sake of clarity.) *g*, gonimoblast; *sp.f*, sporogenous filament; *cps*, developing carpospores; *st.f*, remains of sterile filament.

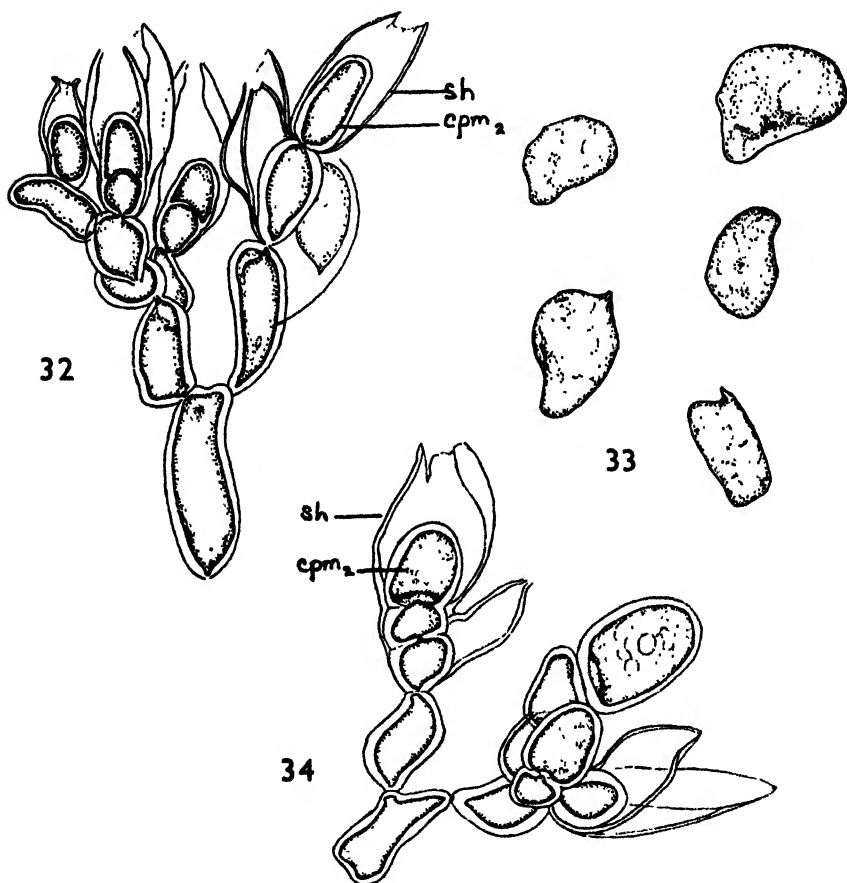
During this process the filaments have branched near the base (the beginning of this can be seen in figs. 28–31), and these branches, together with those growing up from the 'lobed cells' further down, produce the carpospores. It is proposed to call these vertical rows of cells giving rise to carpospores the 'sporogenous filaments', a term proposed by Svedelius (1933) for similar structures in *Asparagopsis* and *Bonnemaïsonia*. This author makes a distinction between the 'primary gonimoblast' which consists of rounded cells, and in



FIGS. 28–31.—Parts of vertical sections through gonimoblast lining cystocarpic cavity, showing degeneration of 'sterile filaments'. 28, narrowing of cells in lower parts of filaments,  $\times 800$ . 29, 30, & 31, older stages; filaments with shrunken degenerated tips,  $\times 1200$ .

*Asparagopsis* produces a massive 'gonimoblast placenta', and the long narrow 'sporogenous filaments' which arise from this and produce the carpospores. In *Bonnemaïsonia*, the 'gonimoblast placenta' is less massive and is represented by a disc of cells, but there is the same distinction between the rounded isodiametric cells of the primary gonimoblast and gonimoblast-placenta, and the

long narrow cells of the erect sporogenous filaments. The construction of the cystocarp in *Chaetangium*, with its massive gonimoblast, is very different from these two genera, but there is the same distinction into a basal layer of rounded cells which produce vertical rows similar to themselves (this it is proposed to call 'primary gonimoblast') and the vertical filaments arising later as branches



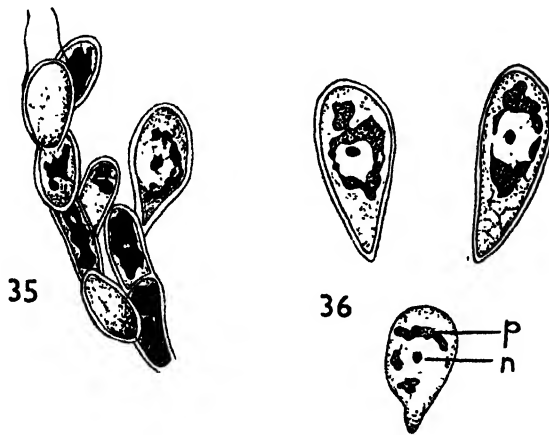
FIGS. 32-34.—In 32 and 34, sporogenous filaments bearing carpospores (teased out from hand sections of cystocarp). Regeneration can be seen through the empty sheaths of old carposporangia. 33, carpospores after liberation; *sh*, empty sheath; *cpm<sub>2</sub>*, secondary carposporangium.  $\times 1200$ .

from the primary gonimoblast cells; these are long and narrow, correspond to the sporogenous filaments of *Asparagopsis* and *Bonnemaïsonia*, and finally produce the carpospores.

The carpospores are borne either on long branching tufts of sporogenous filaments which project into the cystocarpic cavity, or on short branches

consisting of a few cells which line the floor. The terminal cell of each branch becomes a carposporangium, and most of the component cells grow out laterally to form one- or two-celled branches which terminate in carposporangia, so that a dense tuft is formed (figs. 32 & 34). The contents of the carposporangium is at first attached by a well-marked pit-connexion to the cell below; as it increases in size, however, the wall becomes thicker and the pit-connexion disappears. Often a shallow depression is left at the base of the carpospore (fig. 34) or at a later stage the base becomes pulled out into a point (figs. 35 & 36).

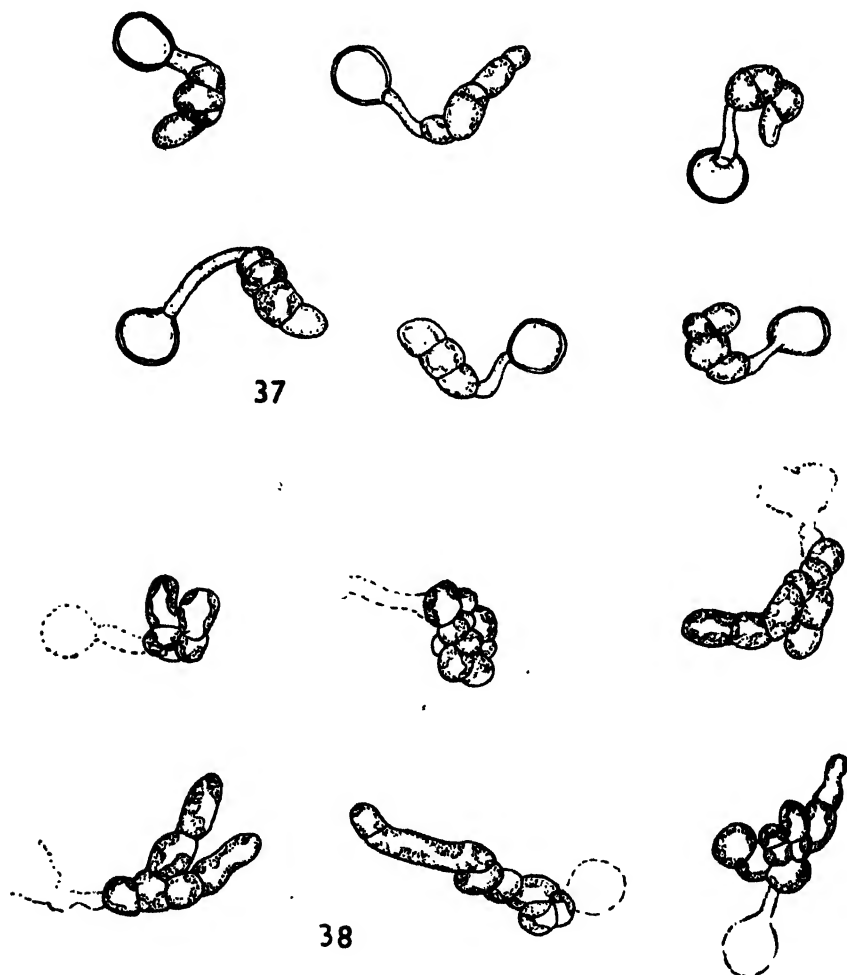
When the carposporangium is mature, its wall splits at the tip, and the whole contents emerge. The pointed base can often be seen in carpospores lying freely in the cavity; the shape of these carpospores suggests that they are relatively soft and possibly capable of amoeboid movement (fig. 33), as has



FIGS. 35 & 36.—From microtomed preparations. 35, sporogenous filament, and 36, carpospores (the upper two still enclosed in the carposporangium wall). *n*, nucleus; *p*, plastids.  $\times 1200$ .

been observed for other genera by Chemin (1929) and Rosenvinge (1927). The ruptured walls of the empty carposporangia can easily be seen, each with a hole or irregular tear where the carpospore has escaped; these are quite evident in microtomed sections, but their number and position are best seen in hand preparations (as shown in figs. 32 & 34), where the carpospore-bearing filaments have been teased out and the walls swollen in glycerine. From the figures available it would seem that many workers have confined themselves to microtomed preparations and have overlooked or ignored the walls; Cleland (1919) and Wolfe (1904) give figures of *Nemalion multifidum* showing empty carposporangia, and Kjellman (1900) in *Galaxaura magna* shows the upgrowth of secondary carposporangia through the empty walls; in Svedelius's work on *Scinaia*, *Asparagopsis*, and *Bonnemaisonia*, however (1915 and 1933),

and in Kylin's figures of carpospores, no walls are shown. It is clear from the figures of *Chaetangium* given here (figs. 32 & 34) that regeneration occurs frequently through the empty sheaths; secondary and even tertiary carposporangia are often seen, growing up inside the empty walls.



FIGS. 37 & 38.—Germinating carpospores. 37, one week, and 38, six weeks, from time of liberation from cystocarp.  $\times 675$ .

The carpospore is evidently naked when liberated; it has a number of irregular plastids and a nucleus. The plastids are visible in the component cells of the sporogenous filaments, where they are irregular and deeply-staining; they increase in size in the developing carpospore and take the form of irregular discs or bands. The small nucleus is sometimes obscured by the plastids

and difficult to distinguish from them; frequently, however, the plastids surround it in the form of a ring (fig. 36). The Feulgen reaction (cf. McClung, 1919, and Westbrook, 1930) has been found useful for differentiating between nucleus and plastids in the carpospore; the nucleus stains a homogeneous pink, while the plastids are completely unaffected, and take on the colour of the counterstain.

An interesting problem is presented by the means of liberation of the carpospores from the cystocarpic cavity. Observations on the shore have shown that a mass of mucilage containing the carpospores exudes from the ostiole when the plant becomes dry during a period of exposure. The ostiole, however, is often very small, being lined with cortical filaments and more or less plugged with mucilage; the result is a deep narrow channel, its width only slightly exceeding the diameter of the carpospores, and its depth several times their length (cf. fig. 5, Plate 1). Obviously, there must be a considerable pressure to force the carpospores out of this opening. It has been suggested to me that this may perhaps be provided by the accumulation of gases in the hollow centre of the plant (cf. bladders of *Ascophyllum*, Damant, 1937); any contraction of the thallus on drying would then cause a positive pressure on the lower part of the cystocarp which projects into the central cavity. This must await experimental proof, but it seems probable that such a pressure would succeed in compressing the cystocarp and in forcing out any carpospores which were lying freely in the cavity. It is worthy of note that, although liberated carpospores are often found in the conceptacle, they have never been seen in the narrow ostiole leading out of it: if the above explanation is correct, the slitting up of the plants for fixation would of course release the pressure, and any carpospores on their way out would probably be drawn back into the cavity again.

During an examination of fresh material, it was found that the carpospores germinated readily, giving small three- to four-celled plants in the course of the first week (fig. 37). After this growth was extremely slow under the conditions of culture, and although the cultures were kept for nearly two months the plants were still small branching filaments of eight or nine cells each (fig. 38). In many of them, however, there was a tendency to the formation of a compact group of cells, doubtless representing the basal disc from which the mature plant would arise.

#### DISCUSSION.

Several points of interest arise from a consideration of the female plants of *Chaetangium saccatum* and a comparison of their development with that of other types.

The young four-celled carpogonial branch is very similar to the three-celled branch of *Scinia*, or, as far as can be seen from the only figure available, to that of *Galaxaura*. As in those genera, several cells are cut off from the lower cells of the branch before fertilization, and the appearance of the carpogonial branch at the time of fertilization (assuming that such occurs in *Chaetangium*)

is very suggestive of *Scinaia*. The five or six large cells of the 'hypogynous disc', with their abundant contents, recall the four-celled disc in *Scinaia*, and the short chains of cells cut off from the third cell of the branch are at first sight very like the 'wall filaments' of that genus.

The subsequent history, however, shows important differences. It has been shown above that there are evidences of the migration of a 'fusion nucleus' from the carpogonium into the hypogynous cell immediately below. This is the course of events shown by Svedelius in *Scinaia* and *Asparagopsis armata*, and the figures of *Chaetangium* are very similar to those of Svedelius for those two genera. In its subsequent development, however, *Chaetangium* differs from *Scinaia* and resembles *Asparagopsis armata*, for the gonimoblast is budded out laterally from the hypogynous cell, while in *Scinaia* the nucleus initiating the process returns to the carpogonium and the gonimoblast originates from there. In *Bonnemaisonia asparagoides* the fusion nucleus is retained throughout in the carpogonium and there undergoes reduction, so that the gonimoblast arises directly from the carpogonium, as it does in the simpler types such as *Nemalion* and *Batrachospermum*.

It has not been possible to demonstrate conclusively the nuclear phenomena associated with this process in *Chaetangium*, but, as shown above, the evidence available points to the conclusion that reduction division takes place in the hypogynous cell, and that of the four resulting nuclei only one is utilized in the production of the gonimoblast. The 'degenerating nuclei' in the hypogynous cell are very similar to those figured by Svedelius for *Scinaia* and *Bonnemaisonia asparagoides*, where also three of the nuclei of the meiotic tetrad degenerate. In *Asparagopsis*, which resembles *Chaetangium* in the point of origin of the gonimoblast, Svedelius has shown that only two of the nuclei degenerate, while two give rise to the gonimoblast filaments. As pointed out by Svedelius (1933), we can trace a series in this respect, from *Batrachospermum*, the only genus in which all four nuclei are known to survive; *Nemalion*, where the reduction division is never completed, but one of the nuclei formed at the first division proceeds no further; *Asparagopsis armata*, where two regularly survive and two degenerate, and finally *Scinaia*, *Bonnemaisonia asparagoides*, and now probably *Chaetangium saccatum*, where three degenerate and only one is utilized. In *Asparagopsis armata*, Svedelius considers that the two nuclei which survive are true sister nuclei, resulting from the second division of meiosis, and therefore having the same genetic constitution, and that 'on the presumption of genotypic sex-determination the result would be that all carpospores from the same cystocarp must have the same sex, either all female or all male'. Similarly in *Chaetangium*, which is strictly dioecious and where only one nucleus of the tetrad survives, one would expect all the carpospores from one cystocarp to produce plants of the same sex\*.

\* It is interesting to note in this connexion that the plants often grow in closely compacted groups, the members of a group being all of the same sex; this is very suggestive of the germination side by side of a number of carpospores liberated from the same conceptacle.

The question of terminology naturally arises in connexion with the hypogynous cells of these genera. There are here quite evidently three types: those such as *Bonnemaisonia asparagoides* where the hypogynous cell is purely nutritive in function and transmits its contents together with those of adjoining 'sterile cells' through a widened pit-connexion into the carpogonium; those such as *Asparagopsis* and *Chaetangium* where the hypogynous cell is also the starting-point of the young gonimoblast, and an intermediate type shown by *Scinaia* where the hypogynous cell only temporarily houses the fusion nucleus, the gonimoblast ultimately arising from the carpogonium above. The question is which, if any, of these is to receive the designation of 'auxiliary cell'. Svedelius (1933) has discussed this point at some length. He points out that when Schmitz (1883) first proposed the term 'auxiliary cell' he included forms like *Naccaria*, where the carpogonium fuses with nutritive cells in the carpogonial branch, whether or not these are also the seat of gonimoblast formation. Later workers, however, have tended to restrict the term to cells with the latter function, and Kylin (1928) makes a sharp distinction between what he calls 'typical auxiliary cells' which function for the origin of the gonimoblast, and 'nutritive cells' which have a purely nutritive function. He enforces this distinction rigidly, and bases his main classification of the Florideae on the presence and character of these 'typical auxiliary cells' (1932). In this classification the Nemalionales and Gelidiales are characterized by the absence of 'typical auxiliaries'; Kylin refuses to apply the term to any of the genera investigated in the Nemalionales. This interpretation, however, is difficult to understand. In the *Bonnemaisonia* type, the hypogynous cell is quite clearly of the 'nutritive' class, and in *Scinaia*, where it only temporarily houses the fusion nucleus, the terminology might be held in some doubt; but in *Asparagopsis armata* (and now in *Chaetangium*), where the gonimoblast undoubtedly arises from the hypogynous cell, the term 'typical auxiliary cell' would seem, on Kylin's own definition, to be directly applicable. This is the view taken by Svedelius for *Scinaia*, and he considers that in *Asparagopsis armata* the case is even more clear, and that 'this species has a typical auxiliary cell in Kylin's more limited sense also' (1933). I should entirely agree with this interpretation; if we adhere to Kylin's definition of a 'typical auxiliary cell' it is difficult to understand his rejection of the term for *Asparagopsis armata*, where he states that 'according to my opinion this cell ought not to be called a typical auxiliary cell' (Kylin, 1935).

*Scinaia* and *Chaetangium* are the only two genera where a number of hypogynous cells is present, forming a 'hypogynous disc'. Svedelius considers that the remaining cells of the disc in *Scinaia* (excluding what we may call the 'true' hypogynous cell into which the fusion nucleus passes) are nutritive in function; he shows open pit-connexions between them and the hypogynous cell and carpogonium, but their assimilation never seems to proceed very far, for figures of the mature cystocarp show these cells still quite distinct at the base, and up to quite an advanced stage of development their contents appear



little changed. The condition in *Chaetangium* is very similar. The remaining hypogynous cells have dense contents and become multinucleate; widened pit-connexions can be seen for some time between them and the true hypogynous cell, but often they are seen, still rich in contents, at the base of quite well-developed cystocarps. At maturity, however, they are lost, the large and extremely complex gonimoblast in this genus having completely obscured them. It seems probable that in both *Scinaia* and *Chaetangium* there is little nutritive material contributed by the hypogynous cells to the developing gonimoblast. These may originally have had an important nutritive function, but in *Chaetangium* there is every reason to suppose that the gonimoblast is at an early stage capable of photosynthesis; the cells of its vertical filaments undoubtedly contain plastids, and it must soon become more or less self-supporting, in which case the nutritive material of the hypogynous cells would be no longer needed. It would be interesting to know if a similar condition obtains in *Scinaia*; it is suggested by the retention of contents and identity of the hypogynous cells, but Svedelius does not mention the occurrence of plastids in either the cystocarpic wall or the developing gonimoblast, neither do his figures show them, although they are usually present in the ripe carpospores of the Florideae.

The feature in which, however, *Chaetangium* stands apart from all the other genera known, is in the construction and complexity of the gonimoblast. The cystocarp of the Chaetangiaceae was considered by Schmitz to be surrounded by a firm and distinct wall, and this has been shown in the genera so far examined in detail. In the *Scinaia* group the gonimoblast radiates out from the base, and is entirely free from the wall; in the Chaetangiaceae, however, it has been assumed that Schmitz's account of *Galaxaura* and *Chaetangium* is correct, and that the gonimoblast creeps round the inside of the wall and forms a lining layer. The construction of the gonimoblast in *Chaetangium saccatum* described here, therefore, comes as a complete surprise; for it is shown (and it is thought shown conclusively) that there is in the mature cystocarp no 'wall' at all, but that the whole tissue surrounding the cavity is composed of numerous interwoven gonimoblast filaments. This is a much more massive and more highly differentiated gonimoblast than any hitherto seen in the Nemalionales. It is evidently capable of photo-synthesis; the early appearance of plastids, and the lack of utilization of storage material in the carpogonial branch, indicate that it becomes to a large extent self-supporting at an early stage.

The only other member of the group showing any differentiation of the gonimoblast at all comparable with that seen in *Chaetangium* is *Asparagopsis armata*. The construction is quite different, for the gonimoblast in *Asparagopsis* is a much smaller structure, and radiates outwards from a central mass; it is enclosed by a wall formed mainly from the surrounding thallus tissue, with however a contribution from the lower cells of the carpogonial branch. The gonimoblast is differentiated into a large-celled central part, which Svedelius calls the 'gonimoblast-placenta' and arising from its periphery the long narrow 'sporogenous filaments' which produce the carpospores. Svedelius compares

this differentiation with that which occurs in other Florideae, e.g. *Gracilaria*, where a central part of the gonimoblast is distinct from a peripheral spore-bearing part. In *Chaetangium*, the form of the gonimoblast, as has been shown, is quite different, but there is the same differentiation into a basal region, consisting here of chains of rounded cells, which project into the centre of the cavity, and a spore-bearing region, consisting of narrow vertical 'sporogenous filaments' which arise from the 'placenta' and ultimately produce carpospores. It has been shown above that the 'paraphyses' of earlier workers are only the early stage of the gonimoblast filaments; later their tips die away, and are replaced by the sporogenous filaments. This dying away of 'sterile' gonimoblast filaments is, as far as is known, without parallel in the Florideae. Their bases are occasionally left as narrow sterile filaments amongst the developing carpospores; they are very similar to the narrow sterile filaments which Svedelius figures for *Asparagopsis armata* and calls 'paraphyses', though in that genus they seem to arise directly from the sporogenous filaments and not to represent the remains of longer structures. Svedelius compares them to the long sterile filaments in the cystocarp of *Gracilaria*; those, however, have a nutritive function when mature, becoming attached to the cystocarp wall, and apparently conveying food material to the developing sporogenous filaments. The 'sterile paraphyses' in *Chaetangium* seem, as far as can be seen, to serve no particular purpose, and are to be regarded as relics of the long sterile filaments originally present. The process may perhaps be compared to that taking place in the development of the conceptacle in the Fucaceae. In that group, one, or occasionally several, sterile hairs are present at the initiation of the conceptacle; later their tips degenerate and from their basal cells arise those cells which eventually line the lower part of the cavity and produce the sexual organs. In this respect the phenomena seem to be comparable in the two widely separated groups.

#### CONCLUSIONS.

The investigation of *Chaetangium saccatum* fully supports the position of this genus as one of the most complex members of the Nemalionales. Although it has not been possible definitely to prove a reducing division, the evidence suggests that it occurs directly after fertilization, and this, together with the absence of tetrasporic plants, shows fairly conclusively that this is a haplobiontic form, with the type of life-history characteristic so far of the Nemalionales. In its structure, however, it is evidently one of the most highly differentiated of that group. Its vegetative construction is reminiscent of that seen in *Scinasia* and *Galaxaura*, with the differences occasioned by a hollow thallus and non-localized apical growth, and is evidently characteristic of the Chaetangiaceae as a family. It is in the reproductive parts, however, that the greatest specialization is seen. The male reproductive organs are borne in small conceptacles, a character which seems to be distinctive of the Chaetangiaceae;

in *Scinaia* the position is quite different, and the antheridia are borne superficially. The male conceptacles in *Chaetangium* are, however, much smaller than those in *Galaxaura*, though until the latter are known in more detail no further comparison can be made. The development of the antheridia and spermatia is on the whole of a regularity which has much in common with the higher Florideae.

With regard to its female reproductive organs, *Chaetangium* again stands amongst the higher members of the Nemalionales. Since no details are known for other members of the Chaetangieae, it is difficult to compare it in this respect; its carpogonial branch is, however, very similar to that of *Scinaia*, and its early post-fertilization development may be compared, as has been shown above, to *Asparagopsis armata*, which is one of the most highly differentiated types known in the Nemalionales. It is in the complexity of its gonimoblast that *Chaetangium* stands apart from other genera. The massive interweaving gonimoblast, surrounding a central cavity and devoid of sterile 'wall', is quite unknown in any genus as yet described. The other genera placed in the Chaetangieae are of interest in this respect. As already mentioned, *Actinotrichia* has a cystocarp more of the *Scinaia* type, where a centrally placed gonimoblast only encroaches slightly on the basal part of the cystocarp—this is very near to the type of gonimoblast described and figured by Setchell for *Pseudoscinaia*, and it is only on account of its similarity in vegetative structure to *Galaxaura* that *Actinotrichia* has been retained in this subfamily. *Whidbeyella* needs much further investigation. The single specimen found by Setchell and Gardner has a mature cystocarp with what these authors describe as 'a gonimoblast uniformly lining the interior of the fruit cavity'. Their figure, however, shows a centrally placed and radiating gonimoblast, whose outer branches are closely adpressed to and seem to 'line' the sterile wall. Obviously further information is necessary with regard to this genus.

We are left with *Galaxaura* and *Chaetangium*, in both of which, it has been thought, from the rather scanty evidence available, that a gonimoblast 'lined' a sterile wall. The data given here for *Chaetangium*, however, raise the important question of the condition in the cystocarp of *Galaxaura*. Apart from Schmitz's account, the cystocarps of this genus have only been described by Kjellman (1900), who found a compact 'wall' of narrow, much twisted filaments, and a 'gonimoblast' of closely packed, richly granular fertile filaments; between these are borne narrow 'paraphyses' (whose origin is not specified). The carpospores are only developed from the fertile filaments. The figures do not show this region in detail, and it is impossible to tell from the description whether there is any real distinction between these sterile and fertile filaments, or whether, as in *Chaetangium*, there is a single structure, all composed of interwoven gonimoblast and bearing first sterile filaments and later fertile ones. This latter condition is certainly suggested by Tanaka's figure (1936) of the cystocarp of *Galaxaura falcata*. This author gives no description, but the cystocarp which he figures is very similar to that of *Chaetangium*. As far as can be seen,

there is no distinction into an outer sterile wall and lining gonimoblast, but the interwoven filaments surrounding the cavity give rise directly to carpospores; near the ostiole there are signs of what may well be 'sterile paraphyses'. The further investigation of *Galaxaura* from this point of view should be full of interest.

Until data for *Galaxaura* are forthcoming, it is not possible to consider fully the position of *Chaetangium* within the Chaetangiaceae. Obviously, the construction of the cystocarp will be the main basis of classification within the family. So far as is known at present, the group Scinaieae is characterized by a sterile wall and a central radiating gonimoblast; it is very much a question as to whether *Actinotrichia* and *Whidbeyella* ought not to be transferred to this section of the family. If *Galaxaura* and *Chaetangium* should both prove to have a cystocarp with a massive gonimoblast and no wall, this character would seem to be sufficiently distinct to merit their separation from the other genera into a separate subfamily. Any final conclusion on this point, however, must necessarily await the further elucidation of the development of the cystocarp of *Galaxaura*.

In conclusion, I should like to thank Miss E. L. Stephens for her constant trouble in collecting, fixing, and despatching material. I am also indebted to the Central Research Fund of the University of London, a grant from which has enabled me to examine fresh material in South Africa.

I wish to express, too, my most grateful thanks to Dr. E. M. Delf and Dr. V. M. Grubb for much encouragement and helpful criticism.

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## EXPLANATION OF PLATE 1.

- Fig. 1. Female plants of *Chaetangium saccatum* showing cystocarps,  $\times 1\frac{1}{2}$ .
- Fig. 2. Microphotograph of vertical section through developing cystocarp,  $\times 325$ .
- Fig. 3. Microphotograph of vertical section through developing cystocarp. The large 'fusion cell' can be seen at the base of the cavity,  $\times 325$ .
- Fig. 4. Microphotograph of vertical section through developing cystocarp, showing darkly-staining hypogynous cells,  $\times 325$ .
- Fig. 5. Microphotograph of vertical section through mature cystocarp,  $\times 85$ .





The development of the sinker of *Orchis mascula* Linn. By B. C. SHARMAN, B.Sc., Department of Botany, University of Leeds. (Communicated by Prof. J. H. PRIESTLEY, D.S.O., B.Sc., F.L.S.)

(With 12 figures in the text)

[Read 27 October 1938]

GENERA of the Ophrydeae, in which are included *Ophrys*, *Orchis*, *Habenaria*, *Platanthera*, etc., perennate by means of swollen, underground structures termed by various authors tubers, tubercles, droppers or sinkers. In the present paper the term sinker is used to cover the whole organ, including its attachment,

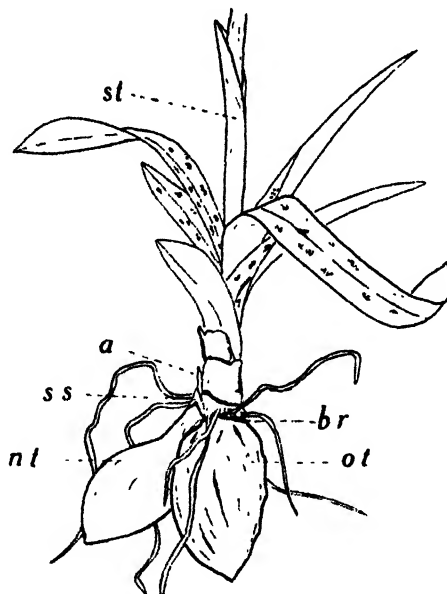


FIG. 1.—Plant of *Orchis mascula* in April.

*st*, flowering stem; *a*, tip of the first leaf of the sinker; *ss*, split scale; *br*, brown ring; *nt*, new tubercle; *ot*, old tubercle.

bud and storage region. The sinkers vary to some extent in shape, size, and general appearance from species to species, but they are all essentially similar in construction. Various interpretations have been offered as to the nature of these tuberous structures, but no generally accepted conclusion has been



reached, and the present detailed examination of the development of the sinker of *Orchis mascula* has been carried out with a view to throwing further light upon this question.

Previous papers on the subject are listed at the end, though some are not specifically referred to in the text.

*Material and methods.*—The material, which was collected mainly from three localities near Worcester during the spring and summer of 1934, was fixed in Langlet's modification of Navaschin's solution (a formalin-chromacetic fixative). Other specimens collected over the same period were potted with as little disturbance as possible and sunken in a grass bank facing south. During potting, the details of the specimens were noted, so that when the aerial parts of the plants had died down later in the year, a supply of plants was accessible and forward or retarded specimens could be taken as required.

Some difficulty was experienced in microtoming the material as many of the sinkers were as much as 0.5 cm. in diameter. Chloroform was found preferable to xylol for the impregnation process as less hardening was caused. In some particularly difficult cases the sections would come away as lace-like fragments, and it was only found possible to obtain entire sections by the following procedure. The face of the wax block was painted with 10 per cent. alcohol with a soft camel-hair brush. After this had remained on for about 30 seconds it was blown off, and it was found that three to five sections could be cut: these appeared crumpled, but, when floating out, the ends of the short ribbons were gently pulled apart with small paint-brushes, and the middle one or two sections were uninjured and expanded properly. By this means a series including about every third or fourth section was obtained.

Other specimens were cleared in chloral hydrate, followed by melted phenol, but though very clear preparations were obtained, the general structure was too complex for much use to be made of this method.

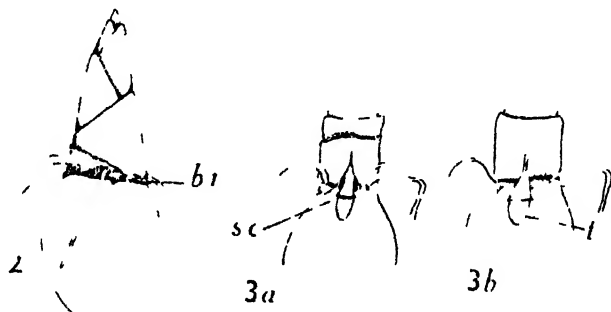
*Morphology.*—A plant of *Orchis mascula* dug up during the flowering season, about April or May, shows the presence of two sinkers at the base of the plant (fig. 1). One of these is situated directly below the leafy shoot and also is browner, slightly withered, and obviously in process of depletion, whilst the other is whiter, usually rather smaller, firmer in texture, and clothed with fine hairs.

Immediately above the swollen region of the parent sinker is a brown ring, which marks the position of the first two scale leaves borne by this shoot. The daughter sinker is associated with the third scale above the brown ring, at the level of which it is attached to the parent axis by a tubular 'stalk'. Above this level the parent axis bears about three more scales, about five or six foliage leaves, and then the bracts subtending flowers. As a general rule it was observed that older plants were earlier in flowering, bore larger sinkers, and the daughter sinkers were attached by shorter stalks, whilst the less mature plants were later in flowering and had smaller sinkers and longer attachment stalks. The attachment stalk is commonly about 0.5 cm. long, but in one case reached 2.5 cm.

A crop of unbranched roots arises from the crowded nodes of the lower part of the parent axis.

Later in the season, about the middle of August, when the leaves of the parent plant die down, the attachment tube of the daughter sinker disintegrates and, as it does so, it is seen to give rise to a brown ring similar to that observed on the parent axis, and at the same time the main bud of the daughter sinker is exposed as in fig. 2.

Dissection of the sinker-bud at this stage shows that all parts of the shoot to be expanded in the following spring are already present, including the flowers and an axillary bud in the axil of the third scale above the brown ring (actually the fifth borne by the shoot). From this time the sinker shows little external change until the following spring, but dissections at intervals through the winter show that during this period the axillary bud continues its development to form



FIGS 2 & 3—2 *Orchis mascula* in September, showing the brown ring, *br*, left by the decay of the attachment tube. 1½ 3 In February, showing the axillary bud developing into a new sinker, (3 *a*), breaking through the base of the subtending leaf, (3 *b*), with the subtending scale removed and showing the first leaf on the bud,  $\times$  2: *sc*, split coleorhiza, *t*, tubercule.

the daughter sinker for the next season. (Actually three generations of sinkers are present, see Table on p. 148) Occasionally buds are also present in the axils of scales 1 and 2, but normally these remain small and do not show the development into a sinker characteristic of the bud in the axil of the third scale.

The bud in the axil of the third scale is distinguished by the fact that the basal part is more swollen, firmer in texture, and is usually of a whiter appearance owing to the production of the root-like storage region of the sinker, which may be described as the tubercule. The growth of the bud and tubercule continue through the winter: in January the base of the subtending scale is split and the developing sinker is seen protruding through it (fig. 3). Through the months of February and March the sinker grows in length and diameter and pushes its way outwards and downwards through the split in the subtending scale. A comparison of figures 4 and 7 shows that the first leaf

of the bud remains attached to the parent axis and that the attachment stalk of the daughter sinker is in continuity with and part of this first leaf. In the early stages the swelling tubercule of the young sinker is covered with a thin membrane, the coleorhiza, composed of superficial tissues of the axis of the parent stem. With further development this is ruptured, its former position being marked by a ring on the young sinker (figs. 6, 7, 3).

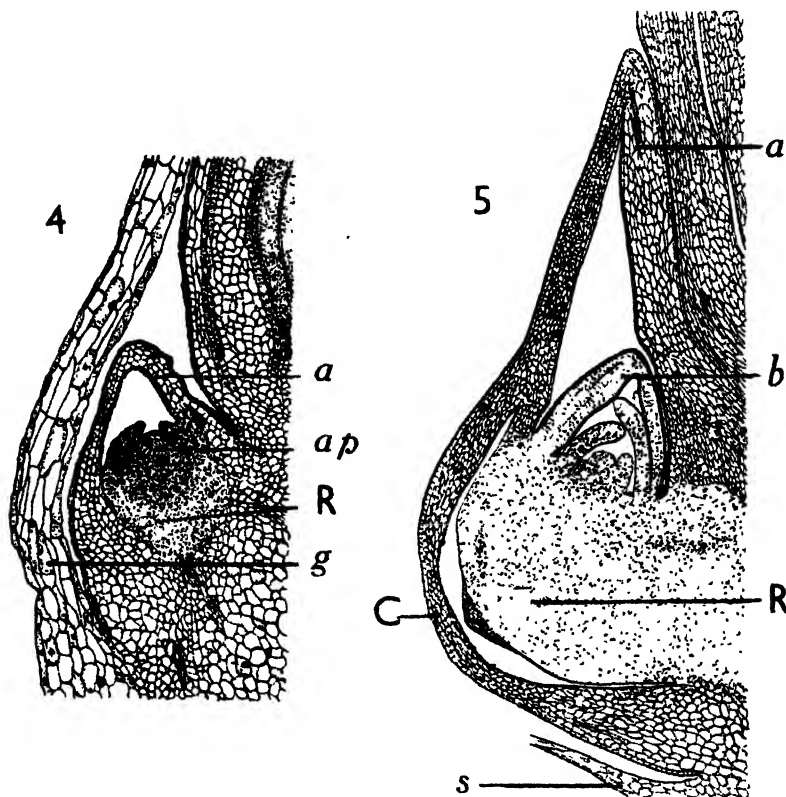
During the early spring months the main shoot of the younger sinker shown in figs. 1 and 2, which is now the parent axis for the new season, pushes up above ground, a few more lateral roots grow out, the leaves are expanded, and by mid-April the shoot is flowering. During this period the growth of the developing axillary sinker has mainly taken the form of elongation and swelling of the attachment tube, but when the leaves of the parent shoot are expanded and assimilating, the tube-growth ceases and further development is mainly in the swelling up of the tubercule, which usually exceeds finally the size of that of the parent shoot. For two or three weeks during the flowering period the new sinker increases

Month.	1st Generation.	2nd Generation.	3rd Generation.
May.	In flower.	Leaves and flowers forming.	
July.			
August.	Leaves die.	All leaves and flowers formed. Separation from parent and bud exposed.	Formed as axillary bud.
September.	.....	.....	Vascular strand of first leaf.
October.	.....	.....	Three or four primordia present.
May.	.....	.....	Tubercule develops.
August.	.....	.....	More leaves and the flowers formed.

in size enormously, but towards the end of April its further increase in size slows down, but does not cease until well into June or July. When food storage in the tubercule is completed, the bud resumes growth and breaks through its attachment-tube, and by the end of July all the foliar structures have been formed at this apex and flower production is in progress. Dissection of this bud in July reveals the presence of the bud which will form the sinker and shoot of the next generation.

On the shoot the first foliar structures are arranged in alternate or  $\frac{1}{2}$  phyllotaxis, the new sinker-forming bud forms in the axil of the third scale (or fifth if the two scales which contribute to the formation of the sinker attachment tube are included), and since the first leaf on the axillary bud is opposite the subtending leaf, the sinker of the third generation will commence its development on the side towards the old depleting sinker of the first generation, which it pushes aside to occupy the same position. Therefore in clay soil it

is common to find two chambers beneath the orchid plant, each one being occupied in alternate years by the decaying sinker giving place to the new one. In clay soil the stiff nature of the medium probably exerts some moulding influence upon the position of the sinkers, for practically without exception only the two cavities are found, and the plant merely undergoes an oscillating movement from one season to the next. Under cultural conditions in looser

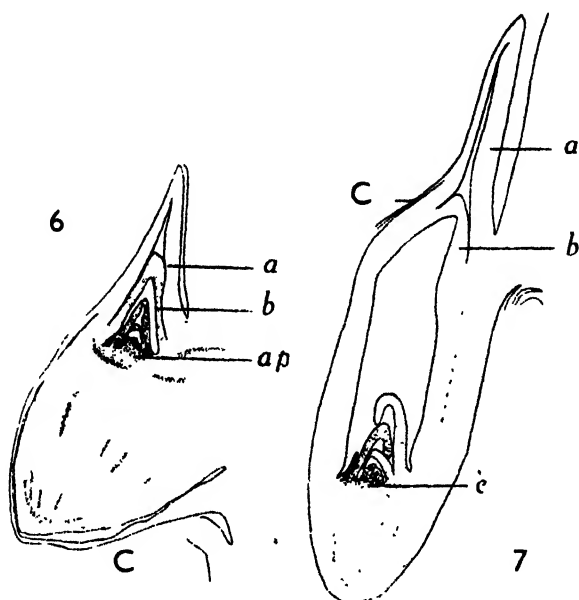


FIGS. 4 & 5.—Longitudinal Sections. 4. Of the axillary bud in September which will form the next sinker. The first two primordia are present and *R* indicates the region which will tuberize: *a*, the first leaf; *ap*, apex of new stem; *g*, subtending scale,  $\times 30$ . 5. Of the tuberizing bud at the end of January,  $\times 12$ : *R*, root; *a*, first leaf; *b*, second leaf; *C*, coleorhiza.

soil it is occasionally found that the successive sinkers follow one another in a spiral, when the phyllotaxis of the parent shoot has changed from  $\frac{1}{2}$  phyllotaxis to a higher spiral rather sooner than is usual. This early change to spiral phyllotaxis is frequently observed in *Orchis Morio* Linn.

*Development.*—The main phases of development of the young sinker may be followed readily by comparison of the stages illustrated in figs. 4, 5, 6, & 7.

At first the bud to form the new sinker has the normal appearance of an axillary bud, and the primordia of the first two foliar structures are seen in fig. 4. By October three or four primordia are present at the apex; the production of primordia then ceases for a time, but a region marked *R* in fig. 5, just behind the bud-apex, becomes actively meristematic, and produces a massive tissue which pushes the covering axial layer of stem-tissue forming the coleorhiza outwards and downwards until it is finally ruptured. The developing tubercle soon assumes an ovoid form, and structural examination of the growing tissues behind the blunt apex shows this to have the general characteristics of a root-

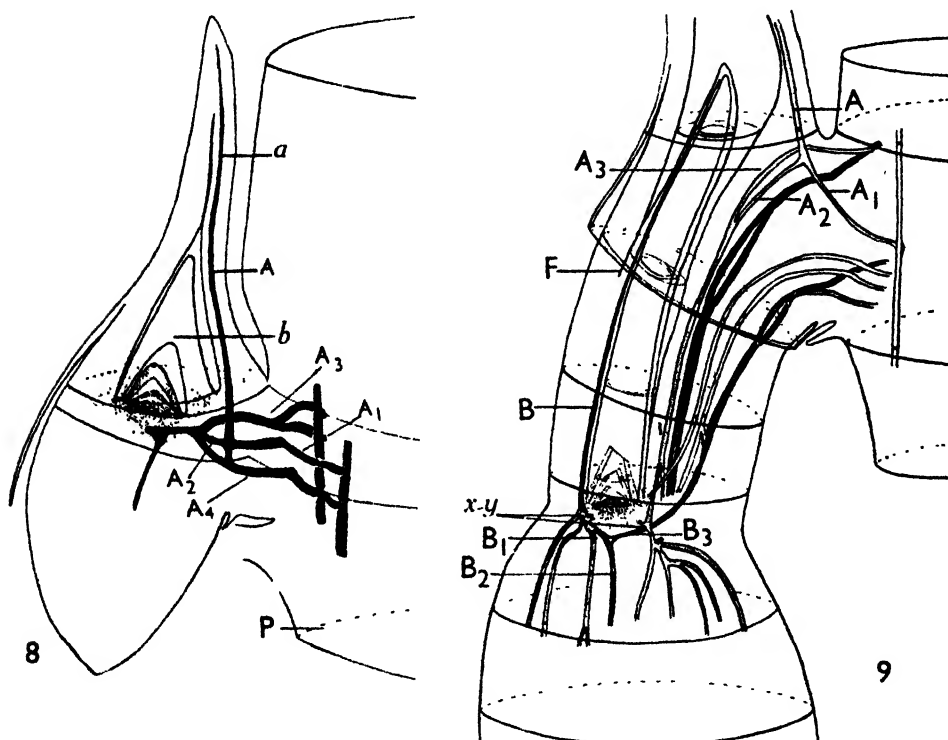


FIGS. 6 & 7.—Longitudinal Sections. 6. Of the tuberizing bud early in February. The tubercle is developed like a root-apex and the coleorhiza is much stretched,  $\times 15$ : *a*, first leaf; *b*, second leaf; *ap*, apex; *C*, coleorhiza. 7. Of the young sinker in March, showing the elongation of the sinker-tube,  $\times 5$ : *a*, first leaf; *b*, second leaf; *c*, bud; *C*, coleorhiza.

meristem. The actual apex is occupied by a small cone of vacuolated cells which have been cut off from the underlying meristem, which is dividing, mainly by transverse divisions, to add to the tissues within. The meristem here has, therefore, the structure of a relatively wide root-meristem of the transverse type. No normal initials of lateral roots are found associated with the nodes on the bud comparable with those which grow out into the lateral roots shown in figs. 1, 2, & 3.

Comparison of these figures also illustrates the development of the attachment-tube of the sinker. In fig. 4 it is evident that the tissues of the first scale of the

bud are already vacuolating. By the stage shown in fig. 7 the basal tissues of this scale and of scale 2 have undergone considerable elongation by vacuolation and cell-division to form the tube of the sinker, and this growth carries the main apex of the bud, with the younger scale and leaf primordia, away from the parent axis, through the split subtending scale and split coleorhiza, deeper into the soil. During March and April the tubercle is considerably enlarged by the accumulation of mucilage as a reserve substance.



FIGS. 8 & 9.—Diagrammatic representations. 8. Of a developing sinker about February, showing the connexion of the vascular supply of the first leaf of the bud with the axis,  $\times 15$ . 9. Of the vascular connexions of the young sinker in April,  $\times 5$  (see text). *a*, first leaf; *b*, second leaf; *P*, parent axis; *F*, fusion of the first and the second bud-leaves; *A* and *B* and *x-y*, vascular bundles, for details of which see text.

The main period of food-storage is followed about May by resumption of activity at the bud-apex, when foliar structures continue to form and ultimately flower primordia are developed.

Though comparison of figures 4 to 7 makes it clear that the attachment-tube is mainly composed of the basal regions of scales 1 and 2, which show some degree of coalescence either on one or both sides of the tube, it is also evident

that the part which has elongated has also developed over the region where the bud made connexion with the parent axis, and it seems evident that the part of the tube towards the parent axis must also include some tissue of the parent axis, a point which becomes still more evident when the course of the vascular bundles is traced from the parent axis into the scales 1 and 2 of the bud.

*Anatomy.—Vascular supply of the sinker.*—The vascular supply of the sinker is too complex to trace in full detail, but some idea of the general arrangement of the bundles may be formed if stages of development are followed. In September the first leaf of the sinker-bud is the only one to have differentiated vascular strands. Fig. 8 shows the relation of the median bundle of the first bud-leaf, A, with the parent axis. At the level of the sinker-bud apex this bundle is connected by the branch  $A_1$  with the parent axis. Before  $A_2$  reaches the bud meristem it is joined by bundles  $A_3$  and  $A_4$ , which also have connexion with bundles of the parent axis.

By the following April the already complicated anatomy of the attachment of the sinker is rendered still more complex and difficult to follow by the

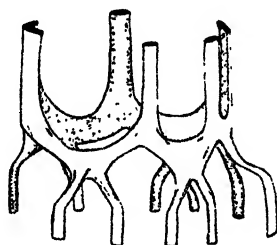


FIG. 10.—*Orchis mascula*. Diagram to illustrate the behaviour of leaf-trace bundles at the node above the tubercle, bud-leaves above, tubercle below.

development of lateral roots from the same node of the parent axis. Fig. 9 is a much simplified, diagrammatic representation of the vascular structure at this time. It is possible to recognize the median strand of the first leaf, A, and its connexion through the strand  $A_1$  with a bundle of the parent axis. The continuation of A as  $A_2$ , which followed a horizontal path at the stage figured in fig. 8, has now been diverted downwards with the extension of the sinker-tube and associated lowering of the bud-apex. The linkage of the strands  $A_2$  with  $A_3$  is probably comparable with the linkage similarly lettered in fig. 8.

Beneath the bud meristem the bundles undergo complex anastomosis in the region which may be regarded as the crowded nodes of insertion of the tube-forming leaves 1 and 2 of the bud. The general behaviour of leaf-trace bundles at the node is illustrated in fig. 10. A bundle of the leaf-trace forks at the node, and each arm links with a similar one, from the adjacent trace-bundle. Also other branches, not shown in fig. 10, are given off into the central region. All these bundles are then continued down into the tubercule, where they undergo further forkings and anastomoses to form a complex network with elongated meshes.

The median trace-bundle of leaf 1 (on the side next the parent axis) and that of leaf 2 (away from the parent axis) behave in this general way on reaching the complex nodal region (fig. 9), and also there are suggestions that from the same level of forking procambial strands diverge towards the bud meristem, probably to enter leaves which are as yet still meristematic.

We have seen that the median strand A of leaf 1 is linked with strands in the parent axis. This is also true of the median strand B of leaf 2, though the course of the connecting bundles differs in the two cases. The strand B reaches the node, forks in the usual way, and also gives off the central strand  $B_1$ . This strand forks, when one arm,  $B_2$ , runs down into the tubercule, whilst the other,  $B_3$ , runs up through the side of the sinker-tube next the parent axis and ultimately makes connexion with bundles of the parent axis. It is a point of interest when considering the nature of the sinker, that the two first leaves of the bud, the tube-leaves, have connexions through the tube with the parent axis, and this would also be true, less directly, of the subsequent leaves to be formed on the bud, since these appear to be linked with these same connecting strands at  $x$  and  $y$  in fig. 9.

*The vascular supply of the tubercule.*—If the numerous bundles which run down into the tubercule from the complex node are examined in a transverse section of the tubercule about half-way down its length, they are found to be about 30 in number in a tubercule 2 cm. in diameter. Each bundle is surrounded by a well-defined endodermis, in consequence of which they are sometimes described as steles. Each bundle is usually diarch, though occasionally triarch. Each group of xylem consists of two to four rather irregularly arranged elements, which longitudinal sections show to be reticulate or spiral, though occasionally stretched and distorted annular elements are recognized. The phloem is ill-defined and often somewhat distorted.

Owing to the presence of a number of separate 'steles' in the tubercule, the question has been raised as to whether the tubercule should be regarded as a polystelic root or as a fasciation of monostelic roots. If a young and still extending tubercule is examined, it is found that the separate steles can be followed, still distinct from one another, as far as the root-like meristem. If, however, an older tubercule of which the growth is almost completed is examined it is found that on approaching the apex the steles become more meristematic, and at the same time link up, first in twos and threes, and finally all join into a single large stele enclosed in a single continuous endodermis. A peculiarity of the end of the tubercule at this stage is that, although undifferentiated tissue is still present within the apex, this becomes enclosed by the development of a continuous endodermis on the inner side of the root-cap. The development of such a layer is a clear indication that the apex has ceased growth in length, and probably has some bearing on the ovoid form of the tubercule, as compared with the types with an elongated tip as found in *Habenaria*.

The ground-tissue of the tubercule consists of large mucilage-filled cells lying in a network of less expanded parenchymatous cells. The mucilage is obviously the form taken by the storage product, and its development suggests



that it is of the nature of a product of protoplasmic breakdown. Certain of the cells expand without undergoing obvious vacuolation, the protoplasmic contents become less clearly distinguishable and tend more readily to pick up the same stains as the cellulose walls. As the process continues the nucleus disintegrates, and finally the contents of the much distended cells appear as a homogeneous globule of mucilage.

This mucilage fails to give most of the reactions characteristic of gums, etc. In common with most substances of this kind it swells considerably in water, but, unlike the majority, it is not stained by iodine or iodine and sulphuric acid. Cuprammonia has little or no effect upon it, it is unstained by methylene-blue (the usual pectin stain), and does not give the orcin-sulphuric reaction (Molisch). The best positive reaction is with corallin, but for this reaction, instead of the usual corallin in concentrated soda solution, water-soluble aurine was used. If a few drops of this solution are placed on the section of the tubercle and the sections are then washed in water the mucilage is stained a deep red.

#### LITERATURE AND DISCUSSION.

Sir Thomas Browne noticed the presence of the two tubers in *Orchis*, the one old and wrinkled and the other new and fresh, but Irmisch (1850) was the first to study their development in *Platanthera bifolia* Rich. (*Habenaria bifolia* R. Br.). He gave a very complete series of drawings of stages of development as seen with the aid of a pocket-lens. He recognized the fact that the new tuber arose in the axil of the fifth foliar structure on the parent, and realized that this was related to the alternating positions of successive generations of tubers.

Stojanow (1916-18) also recognized the formation of the sinker-tube from foliar structures of the bud, but he does not appear to have realized that more than one leaf took part in the formation of the tube. He described the way in which the vascular strand in the tube-leaf is connected with strands in the parent axis through the anastomosis beneath the bud of the sinker. Nobécourt (1920) recognized that the tube was formed from two leaves.

Though buds are frequently present in the axils of the first three scales above those forming the sinker-tube, there is a general agreement that it is the topmost of these which tuberizes to form the sinker for the next generation. Reference to p. 148 will show that at any time three generations of sinkers are present on an *Orchis mascula* plant; for example, during the period May to August the shoot of the first generation passes through its vegetative and flowering period and the foliage-leaves die down about mid-August; in the sinker of the second generation over this period most of the leaves and flowers are formed in the bud, the tubercle having undergone its main period of expansion and food-storage during the months from October to April; the bud which will be the sinker of the third generation appears about June or July and lays down its first few primordia up to October, when leaf-formation ceases and is replaced

for a time by development of the tubercule. Since the sinker of the second generation is already swollen with food-reserves at the time of maximum vegetative activity of the shoot of the first generation, it seems not unnatural that materials passing out of the dying leaves should be used by the developing bud of the third generation, which is active in the formation of primordia at first and then changes its activity later in the season to food-storage in the developing tubercule. That food is probably an important factor in tuberization of buds is supported by the observations of Prillieux (1867) and Bernard (1902), that if the floral spike is damaged or removed, more than one of the axillary buds tuberize. Similarly, if the newly developing sinker is removed, the next bud below produces a sinker instead; no observation to this effect was found in the literature, but five separate experiments in the course of the present work have yielded this result, though if the sinker is not removed until relatively late, the replacing one tends to be smaller than normal. Another observation relevant to this point is that very occasionally in *Orchis mascula*, if the plant is vigorous and mature, two sinkers may be produced in place of the usual one. Though this is a rare occurrence in this species, Bernard states, on the authority of Fabre, that it frequently occurs in *Loroglossum hircinum* Rich. (*Orchis hircina* Crantz).

In plants of these ground-orchids it is practically unknown for axillary buds to grow out into normal branches without tuberizing, and it has been suggested by Bernard (1902) that this peculiar type of development of the buds may be causally connected with fungal infection, which is normal for these plants. When the bud is separated from the parent in August it is entirely free from fungal infection, but when the roots from this axis reach a length of 1-3 cm. they are invaded by fungal hyphae, which soon permeate the shoot up to a maximum saturation point. At this time the new axillary bud commences to tuberize. It is suggested that the infection of the roots causes a check on their development, so that more food is available for the buds. From this point of view one abnormal case of an *Orchis Morio* plant which had developed a distinctly branch-like structure from an axillary bud is of interest. This bud had undergone appreciable elongation between the first leaf and the attachment of the bud, and though the root-like structure of a normal sinker had developed, the first leaves showed no suggestion of the usual modification into the sinker-tube. Though fungal infection of *Orchis* plants is usually readily observed, no indications of infection could be found in serial sections of this specimen.

Another point which has received considerable discussion in the literature is that of the so-called polystely of the tubercule. There is general agreement that the tubercule is essentially root-like, and this is certainly supported by the similarity of the meristematic apex with that of a root. The difficulty in this interpretation is the presence of numerous vascular strands, each enclosed in its own endodermis; in some cases the structure has simply been described as polystelic, whilst in other instances the interpretation has been carried further and the whole structure regarded as a type of fasciation where a number of

roots have developed into one compound structure, in which they are intimately fused by their cortices. Holm (1904) surveyed a number of North American terrestrial orchids with reference to the characters of their roots, and it appears that he found all tubercles to be 'polystelic', whilst the more slender lateral roots might be either polystelic or monostelic. White (1907) made a more thorough examination of the North American *Habenarias* and found in certain species that the lateral roots were polystelic, but in such cases the roots were monostelic at the base, and only became polystelic nearer the distal end; the apex of such roots was single and gave no suggestion of the fusion of two or more closely situated apices.

An observation that suggests that the polystely may be associated with food-storage in the tubercle is one by Stojanow (1916-18) during an investigation into the mode of origin of the tail-like prolongations of the tubercles of the *Dactylorchids*. In connexion with this work he collected data as to the relative number of steles in the new and old tubercles of plants of *Orchis Morio*, which were at various stages of maturity. As the plants become more mature as successive generations of sinkers are formed, the tendency is for the sinkers to become larger, owing, presumably, to the larger amount of food available for storage, since the parent shoots have progressively larger assimilating surface. Out of 100 specimens of *Orchis Morio*, Stojanow found that the number of steles varied from 15 to 54; in 59 plants the number of steles of the daughter tuber was higher than that of the parent, in 9 it was the same, and in 32 it was lower. Though the evidence is not conclusive, the above observation, and the fact that the steles coalesce at the tip of the tubercle as its growth approaches completion, support the view that polystely is associated with greater meristematic activity at the apex of the tubercle which is linked with a larger food supply.

There seems little doubt that the sinkers of the various genera of the *Ophrydeae* are all essentially similar in construction in spite of considerable variation in the shape taken by the root part or tubercle. The essential similarity is strongly suggested by a study of Irmisch's figures. In *Orchis maculata* and the palmately divided *Dactylorchids* in general the tubercle is divided into a number of 'tails', and the number of these increases with maturity of the plant. At first sight this appears suggestive of the fasciation theory to explain the polystely of the tubercle, but, as Arber (1925) pointed out, the production of the 'tails' appears to be quite independent of the number of steles in the tubercle.

Specialized organs of perennation are common in the herbaceous perennial *Monocotyledons*, and the comparison of various types of bulbs, corms, rhizomes, etc., illustrate how varied may be the part in which food-storage takes place. The structures which show most similarity to the sinkers of the orchids are the droppers of tulips. Fig. 11 illustrates the dropper of a young tulip plant, in which the terminal bud has been lowered by the downward growth of the base of a foliage leaf to form the tube of the dropper. Since the bud is carried down, it is clear that the tube must also include in its structure the region

of the axis situated between the insertion of the dropper-forming leaf and the terminal bud; this is suggested by the dotted line down left side of the dropper-tube. For more details of droppers in *Tulipa*, the paper by A. Robertson, (1906) should be consulted. Comparable with this lowering of the terminal bud in seedling tulips, in *Orchis* seedlings it may sometimes be the terminal bud which is lowered by the sinker formation. In rather more mature tulip plants lateral buds may be lowered by droppers, when, on the side of the dropper-tube next the parent plant, the tube must include, in addition to the tissues of the leaf forming the dropper-tube, also some tissues of the parent axis, including the attachment region of the axillary bud which has been lowered. The two structures are obviously very similar, the two main points of difference being that the orchid sinker-tube is constructed mainly of two leaves, the tulip dropper-tube of one leaf, and whereas the food-storage in the tulip will be



FIG. 11.—*Tulipa* sp. Longitudinal section of a young plant in March showing the lowering of the terminal bud by the tube of the dropper,  $\times \frac{1}{2}$ : *u*, assimilatory part of tube-leaf; *r*, dropper-tube; *w*, bud.

in the scale-leaves of the bud, in the orchid we have the new feature that the storage is in the 'tubercule', a structure which corresponds in structure most closely to an enlarged lateral root initial.

*Summary.*—In spring plants of *Orchis mascula* have two tuberous structures, described as sinkers, at the base, and from the older of these arises the shoot of the current season. Development shows that the attachment-tube of the younger sinker is formed mainly by the first two scale-leaves of the axillary bud, whilst the axillary bud which will form the next sinker is situated in the axil of the fifth scale of this bud.

The elongation of the tube-leaves carries the axillary bud down through a rupture in the base of the subtending scale on the parent axis. The tube includes, on the side next the parent, axial tissues of the region of the bud-insertion. This point is supported by anatomy, since it is found that the

tube-leaves have connexions with the parent axis by bundles running in this side of the tube.

After the first few leaf primordia of the sinker-bud are formed development proceeds in a region below the bud, to form the main region of food-storage known as the tubercule. This appears to have an apical meristem like that of a root, but is peculiar in being polystelic in structure.

Experimental observations suggest that tuberization of the bud to form the sinker is mainly controlled by food-supplies. The infection of the parent plant by fungal hyphae may also affect tuberization. It is suggested that the polystely of the tubercule is probably due to food-storage in this structure rather than to a fasciation of roots in development.

Though varied in shape, the sinkers of the Dactylorchids are of similar construction. The peculiar feature is the storage of food in the enlarged root initial. The lowering of the terminal bud of an *Orchis* seedling or of a lateral bud in more mature individuals by sinker formation is closely paralleled by similar lowering of the terminal or lateral buds of tulips by dropper formation.

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A new conception of the genus *Ammocharis* Herb. By E. MILNE-REDHEAD,  
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(PLATES 2-4 and, in text, 2 figures and 2 maps)

[Read 27 October 1938]

#### HISTORY OF AMMOCHARIS HERB.

At the time of the publication of Linnaeus's 'Species Plantarum' (1753) only one of the species here considered was known, namely *Amaryllis longifolia* Linn. This plant had already been in cultivation in European gardens for well over 100 years, and several figures of it had appeared in pre-Linnaean botanical works. The figure in Hermann's 'Paradisus Batavus' (1698) is a remarkably good portrait of the species, as will be seen by the reproduction of it overleaf (fig. 1). It was on Hermann's illustration that Linnaeus based his *Amaryllis longifolia*. It is unlikely that he saw a living plant of the species, and there is no specimen of it preserved in the Linnaean Herbarium.

Before the end of the eighteenth century, on three independent occasions, the name *Amaryllis longifolia* had been misapplied by botanists when naming South African Amaryllids, and the confusion in nomenclature caused by these misidentifications has unfortunately persisted until the present day.

Thunberg collected two gatherings of plants which he believed to be *Amaryllis longifolia* Linn. He decided that these plants should be placed in the genus *Crinum* Linn., and accordingly he cited them in his 'Prodromus plantarum capensium' under the new combination, *Crinum longifolium* (Linn.) Thunb. As, from his description, it was apparent that Thunberg's plants were not *Amaryllis longifolia*, the two sheets of *Crinum longifolium* in Thunberg's Herbarium were examined by us. Both were found to bear the name *Haemanthus longifolius*. Sheet 1 consists of two leaves not unlike the leaves of the South African plant, *Amaryllis Belladonna* Linn. Sheet 2 consists of three inflorescences of which two belong to *Amaryllis Belladonna*, while the third belongs to *Crinum variable* Herb. On this sheet Thunberg had added a reference to '*A. longifolia* Jacq. Rar. 2, fasc. 12, t. 9 '\*', a figure representing the plant known as *Crinum longifolium*.

\* This is a reference to Jacquin's 'Icones Plantarum Rariorum', a work which was originally published in parts. On completion of each volume these parts were rearranged and numbered according to the Linnaean System, and the text, correspondingly numbered, was then issued. For list of plates in fascicle 12 see review in 'Annalen der Botanik', v, p. 112 (1793).



FIG. 1.—*Cybistetes longifolia*; from Hermann's 'Paradisus Batavus', on which Linnaeus based his *Amaryllis longifolia*.

About the same time living plants of a species of *Crinum* from the Cape were introduced by Masson to Kew, and these were misidentified, both by L'Héritier and by the younger Linnaeus, with *Amaryllis longifolia* Linn., under which name the species concerned was figured on t. 661 of the 'Botanical Magazine'.

The epithet *longifolia* has, up to the present day, been consistently applied to this species of *Crinum*, with one exception. In the text accompanying t. 1443 of the 'Botanical Magazine', Ker-Gawler, although he used a later epithet, correctly identified *Amaryllis longifolia* Linn. with *Crinum falcatum* Jacq., and pointed out that the plant figured on tab. 661 of the 'Botanical Magazine' was a very different species.

Herbert treated *Amaryllis longifolia* in the sense of L'Héritier and the younger Linnaeus, and placed it in *Crinum* under the name *C. capense* (Mill.) Herb., stating that the epithet '*longifolium*' had already been applied to an Asiatic species of *Crinum* by Roxburgh (1832). He overlooked the fact that Thunberg had made the combination *C. longifolium* (Linn.) Thunb. for the Cape plant in 1794.

Baker, in his 'Handbook of the Amaryllideae', ignored Ker-Gawler's treatment of *Amaryllis longifolia* Linn., and followed Herbert in placing it in *Crinum*, but adopted the epithet '*longifolium*'. Similarly the name *C. longifolium* (Linn.) Thunb. was used in Dyer's 'Flora Capensis', but here Baker added the citation of a specimen collected by Thunberg 'Near Cape Town, between the foot of Lion Mountain and the sea-shore, Thunberg!'. It is highly improbable that Baker at any time had seen a Thunberg sheet bearing this information, which is obviously a translation of Thunberg's citation in his 'Flora Capensis', II, p. 264 (1818). The description accompanying Thunberg's citation of *C. longifolium* (Linn.) Thunb. is undoubtedly based on the only two sheets named *Haemanthus longifolius* in Herb. Thunberg (see Juel, Plant. Thunb. p. 71: 1918), which bear no locality.

Baker ignored sheet 1 mentioned above. Sheet 2 bears identifications in his handwriting, and is cited in Dyer's 'Flora Capensis' partly under *C. variabile* (Jacq.) Herb. and partly under *Amaryllis Belladonna* Linn. There can be no justification for retaining the epithet '*longifolium*' for the Cape species of *Crinum* represented by the 'Botanical Magazine', tab. 661\*.

Independently Jacquin, in 1776, had described and figured a plant, cultivated in Vienna, under the name *Crinum falcatum* Jacq. Both L'Héritier and the younger Linnaeus identified quite correctly another plant growing at Kew, also

\* It appears that the correct name for this plant is *Crinum bulbispermum* (Burm.) Milne-Redhead & Schweickardt, comb. nov., based on *Amaryllis bulbisperma* Burm. Prodr. Cap. p. 9 (1768). The names *Amaryllis capensis* Mill. and *Crinum capense* (Mill.) Herb., which are given by Baker as synonyms for '*C. longifolium*', undoubtedly refer to some short-tubed species, and must be excluded, though Herbert's figure in the 'Botanical Magazine', t. 2688 (1826), under the name *Crinum capense* var. *riparia* no doubt shows a form of *Crinum bulbispermum*.



introduced from the Cape by Masson, as *Amaryllis falcata* (Jacq.) L'Hérit., but owing to their misconception of *Amaryllis longifolia* Linn. they failed to recognize that these two plants were conspecific. Thunberg, owing to a similar misconception, also treated *Haemanthus falcatus* (Jacq.) Thunb. as distinct from *Crinum longifolium* (Linn.) Thunb.

As mentioned above, Ker-Gawler appears to have been the first botanist to recognize that *Crinum falcatum* Jacq. is conspecific with *Amaryllis longifolia* Linn. He placed the plant in the genus *Brunsvigia* Heist. as *B. falcata* (Jacq.) Ker-Gawl.

Ker-Gawler, in 1816, described and figured in the 'Botanical Register', tab. 139, a plant which he called *Amaryllis coranica*. This plant had been collected by Burchell in the 'Corana country . . . several days' journey beyond the Orange River'.

Herbert originally placed *Amaryllis falcata* and *A. coranica* in the genus *Brunsvigia* Heist., but, in his subsequent subdivision of *Amaryllis* Linn., he created the genus *Ammocharis*, consisting of the two species, (1) *A. coranica* (Ker-Gawl.) Herb., and (2) *A. falcata* (Jacq.) Herb. He separated the genus from *Crinum* Linn. by the much smaller pollen-grains and by the leaves not sheathing each other at the base, perishing in the winter and the same ones sprouting again in the spring. He stated that the ovules of *Ammocharis*, like those of *Crinum*, adhered inseparably by one whole side to the placenta, whereas in *Boöphone*\* Herb. the placentation was of a different nature.

*Ammocharis* Herb. was not accepted by authors such as Sprengel, Reichenbach, and Dietrich†. Roemer (1847) doubtfully added *Amaryllis longifolia* Linn. to the genus as *Ammocharis longifolia* (Linn.) Roem., and under it he placed Thunberg's description of *Crinum longifolium*, which, as pointed out above, relates to an entirely different plant. Roemer failed to recognize that *Ammocharis longifolia* (Linn.) Roem. and *Ammocharis falcata* (Jacq.) Herb. are conspecific.

\* Wittstein (Etymol.-bot. Handwörterbuch, p. 131: 1856) derives the generic name from *βοῖς* = ox and *φόνη* = murder. Since Herbert's first species was *Haemanthus toxicarius*, Bot. Mag. t. 1217, which is there stated to be fatal to horned cattle, it is clear that Wittstein's derivation is correct. Marloth's derivation (Fl. S. Afr. iv, p. 115: 1915) of the name from 'Bupho' [i.e. *Bufo*]—toad is an uninspired guess.

Herbert, in 1821, spelt the name '*Boophane*', which, in view of the above, is clearly an error for '*Boophone*'. In 1825 (Bot. Mag. post t. 2606) he changed the spelling to '*Buphone*'. The change from 'phane' to 'phone' suggests that *Boophane* was an unintentional error for *Boophone*, which may accordingly be corrected. There is, however, no justification under the International Rules for altering 'Boo' to 'Bu', since the former is the uncontracted stem of *βοῖς*.

† Fritsch (Bull. Herb. Boiss. ser. 2, 1, p. 1108: 1901) states that only in a very artificial manner can one distinguish between *Ammocharis* and *Crinum*. He supports his views by the fact that certain characters (colour of flower, elongated pedicels, and relatively shorter perianth-tube) are not constant in these genera. At the same time Fritsch transfers *A. coranica* Pax and *A. Taveliana* Schinz to the genus *Crinum*. We disagree entirely with Fritsch's views, since he attached weight to characters which, in our opinion, are not of generic importance.

Kunth (1850) followed Roemer in treating *Amaryllis longifolia* Linn. as an *Ammocharis*, but evidently was somewhat doubtful as to whether it was synonymous with *Ammocharis falcata* (Jacq.) Herb., since he placed the former immediately after the account of *A. falcata* without giving it a number. He furthermore pointed out that Linnaeus under *Amaryllis longifolia* included the reference to Hermann's 'Paradisus Batavus', tab. 195, which Kunth himself cited under *Ammocharis falcata* (Jacq.) Herb. Kunth added another species to the genus, *Ammocharis Slateriana* (Herb.) Kunth, which was subsequently placed in *Brunsvigia* Heist. by Bentham and Hooker.

In 1866 the genus *Palinetes* Salisb. was described. It is synonymous with *Ammocharis* Herb., being founded on the same two species.

Bentham and Hooker (1883) limited the genus so to include only *A. falcata* (Jacq.) Herb. and *A. coranica* (Ker-Gawl.) Herb.

Baker, in his 'Handbook of Amaryllideae' (1888), caused further confusion by reducing *Ammocharis coranica* (Ker-Gawl.) Herb. to *A. falcata* (Jacq.) Herb. He stated that the fruits and seeds of the genus were unknown, and suggested that the fruit figured by Ker-Gawler in the 'Botanical Magazine' (t. 1443) was 'that of a *Brunsvigia* mismatched with the flowers'. Baker failed to cite *Ammocharis longifolia* (Linn.) Roem., and placed *Ammocharis Slateriana* (Herb.) Kunth under *Brunsvigia*.

In the same work Baker correctly placed *Ammocharis* Herb. in a small section of his 'Key to the Genera' \* characterized by having 'fruits indehiscent or bursting irregularly' and 'seeds few, green, turgid', although in the generic description he stated the fruits and seeds were unknown!

He distinguished the genera *Amaryllis* Linn. and *Ammocharis* Herb. from *Crinum* Linn. on account of their short perianth-tube, and *Ammocharis* from *Amaryllis* on the width of the perianth-segments.

Pax (1888) followed Bentham and Hooker (loc. cit.) in recognizing only two species. He placed the genus in the subtribe Crininae next to *Crinum* Linn., from which he distinguished it by the flowers having longer pedicels. In the subtribe Amaryllidinae, which he separated from the Crininae by the perianth-tube being very short or absent and by the scape being terete, he placed among others the genera *Nerine* Herb., *Amaryllis* Linn. and *Brunsvigia* Heist. He placed *Boöphone* Herb. in yet another subtribe, the Haemanthinae, distinguished from the above subtribes by having few ovules per loculus. His classification appears to be very artificial.

In the same year Pax added a new species, *Ammocharis coccinea* Pax, without mentioning its relationships to the other species. This was the more surprising since Pax's type had come from the same region as the type of *A. coranica* (Ker-Gawl.) Herb.

Baker (in Dyer, *Flora Capensis*: 1896) continued to treat *A. coranica* as a synonym of *A. falcata*, whilst he took up *A. coccinea* as a second species, conveniently omitting to add a key to these species. Although he retained

\* See also Yearb. Am. Amaryll. Soc. 1, p. 32 (1934).

*Amموcharis* in the same group of genera in which it had been placed in his Handbook (loc. cit.), he distinguished these genera by using somewhat different characters. *Amموcharis* was separated from *Amaryllyis* and the 'Cape species of *Crinum*' by the erect stamens and narrow perianth-segments, characters which apply to several species of *Crinum* some of which are now known to occur in South Africa. *Amaryllyis*, which has a three-valved capsule, was placed in the group of genera having 'fruits indehiscent or bursting irregularly'. *Brunsvigia* and *Nerine* were placed in a separate group on account of the three-valved capsular fruit and many compressed seeds. *Boöphone* was characterized in the synopsis of genera by having two or few ovules clustered at the middle of the placentas, whilst no mention was made of the placentation as a distinguishing character of the other two groups of genera.

Schinz (1890) described *Amموcharis Taveliana* from South-West Africa. This was recognized by Durand and Schinz (1895), and by Baker (in Fl. Cap. Addenda : 1897 & in Fl. Trop. Afr. : 1898) as a third species of the genus.

Thonner (1908 & 1915) recognized two species only, which he distinguished from *Crinum* by the perianth-tube being perceptibly shorter than the perianth-lobes. He separated *Amموcharis* from *Boöphone* by the numerous ovules in each loculus, and from *Amaryllyis* and *Brunsvigia* by the presence of a distinct perianth-tube. He described the flowers of *Amموcharis* as distinctly irregular. His conception of the genus is difficult to interpret, since he recognized only two species and did not indicate which species he had excluded.

Marloth (1915) followed the conception and classification of *Amموcharis* and allied genera adopted by Baker in the 'Flora Capensis'.

Phillips (1926) evidently follows Thonner in accepting only two species for the genus. He separates *Amموcharis* from *Nerine*, *Crinum* and *Amaryllyis* by its ovary being narrowed into a neck; from *Boöphone* it is distinguished by having several (5-6) ovules in each loculus, and from *Brunsvigia* by the globose or obtusely three-lobed ovary.

Pax and Hoffmann (1930), whilst recognizing three species in the genus, more or less follow Pax's earlier classification of the allied genera.

Hutchinson (1934) follows Pax in separating *Amموcharis* from *Crinum* solely on the length of the pedicels.

Traub (1938) places *Amموcharis*, together with *Stenolirion*, *Crinum*, *Callicore* (i.e. *Amaryllyis*), *Brunsvigia*, and *Nerine*, in a new tribe, Callicoreae Traub, characterized by having globose or subglobose seeds. He separates *Amموcharis* from *Crinum* by its long-stalked not subsessile flowers and from *Callicore* by its straight, not declinate, perianth.

#### DIVISION OF AMموCHARIS HERB. INTO TWO GENERA

Herbert's original description of *Amموcharis* is based almost entirely on *Amaryllyis coranica* Ker-Gawler. In the notes following the description Herbert states: 'I have not examined the pollen of *falcata* nor its ovules, since I have

seen those of *coranica* and *toxicaria*; but I believe they will be found to accord with *coranica*, to which the name *Ammocharis* is given'. It is therefore obvious that *A. coranica* is the type of the generic name.

After he had prepared the description of *Ammocharis*, Herbert was able to examine a fine umbel of *A. falcata*, on the basis of which he emended the generic description by adding comments and notes in a postscript and corrigendum to his 'Appendix'. As he had most probably never seen a living plant of either species until after he had drawn up the description, he did not realize that *A. coranica* differed from *A. falcata* in a number of important characters difficult to see in dried material. In the original generic description he had stated that the filaments were 'spreading' and that the 'germ is triangularly turbinate or obovate, continued straight from the ovary', whilst in the corrigendum he modified this to 'filaments and style declined, with the point bent upwards', and 'germ triangularly oblong-oval continued from the peduncle, which is often bent when the flowers are expanded'.

These original characters, which Herbert later thought to be incorrect, actually apply to *A. coranica*, whilst the emended characters apply to *A. falcata*, having been taken from a living plant.

Had Herbert known the mature infructescences and fruits of *A. coranica* and *A. falcata* it is doubtful whether he would have considered these plants congeneric. He strangely overlooked Ker-Gawler's remarks, which accompanied his description of *Amaryllis coranica*, concerning the differences between the fruits of this species and those of *Brunsvigia falcata* (Jacq.) Ker-Gawl. In *A. coranica* there is no appreciable elongation of the pedicels during the development of the fruit, which is a more or less spherical indehiscent 'capsule' almost exactly similar to that of *Crinum*. In *A. falcata* the pedicels increase in length, stiffen considerably, and radiate in all directions, and the fruit is a clavate somewhat triquetrous strongly-ribbed indehiscent 'capsule' somewhat resembling the dehiscent capsule of *Brunsvigia*. This similarity caused Ker-Gawler to place *A. falcata* under that genus (Bot. Mag. tab. 1443).

As stated earlier, Baker suggested that the fruit figured by Ker-Gawler did not belong to the flowering specimen, but probably belonged to a *Brunsvigia*. Even allowing for this supposition it is difficult to understand on what grounds Baker united such very distinct plants.

Examination of recent gatherings of *A. longifolia* (*falcata*) have convinced us that this plant fully deserves generic distinction. The name *Cybistetes* is thus proposed [*κυβιστητής* = tumbler], since the mature infructescence becomes detached and is then tumbled about by the wind.

A key to *Ammocharis* and *Cybistetes* and to some of the African genera allied to them has been drawn up in order to make clear our conception of these genera, and thus to avoid further confusion.

*Artificial key to Ammocharis, Cybistetes, and allied African genera.*

- Leaves distichous, biflabellately arranged, arching or spreading on the ground, growing out again at beginning of new growth-period; all leaves, but younger with truncate apices:
- Flowers actinomorphic; perianth in line with the pedicel; stamens not declinate; pedicels not elongating or changing position in fruit; capsule indehiscent, subspherical, not strongly ribbed, disintegrating entirely ..... **AMMOCHARIS.**
- Flowers zygomorphic: perianth making an angle with the pedicel; stamens declinate; pedicels elongating and the outer spreading downwards in fruit; capsule indehiscent, dry, clavate, triquetrous, strongly ribbed, the ribs persisting ..... **CYBISTETES.**
- Leaves not biflabellately arranged, usually lasting through only one growth-period; if growing out again at beginning of new growth-period, then spirally arranged and sheathing at the base:
- Flowers actinomorphic:
- Ovules 1-6 per loculus; pedicels elongating in fruit; capsule dry, triquetrous, indehiscent or loculicidal ..... **BOÖPHONE.**
- Ovules many per loculus; pedicels not elongating in fruit; capsule membranous, not dry, subspherical, indehiscent or bursting irregularly ..... **CRINUM.**
- Flowers zygomorphic:
- Pedicels elongating in fruit; capsule dry, triquetrous, loculicidal; perianth-tube short or almost absent, often oblique ..... **BRUNSVIGIA.**
- Pedicels not elongating in fruit; if stout or rigid, then capsule not triquetrous:
- Ovary with few ovules per loculus, subglobose, trilobed; capsule subglobose, membranous, loculicidal, less than 1.5 cm. in diameter; perianth-lobes narrowly oblanceolate ..... **NERINE.**
- Ovary with many ovules per loculus; capsule more than 1.5 cm. in diameter:
- Perianth-tube long, narrowly cylindrical; capsule subspherical, indehiscent; perianth-lobes linear to broadly oblanceolate; leaves not distichous or if distichous the inner much narrower than the outer ..... **CRINUM.**
- Perianth-tube very short; capsule subspherical, loculicidal; perianth-lobes broadly oblanceolate; leaves distichous. . . . **AMARYLLIS.**

*Location of specimens examined.*

In preparing the account of these genera all the material deposited in the Herbarium, Royal Botanic Gardens, Kew, as well as that in the British Museum (Natural History) was examined. In addition, several species flowering at the Royal Botanic Gardens, Kew, were examined in the living state. Furthermore, important specimens were received on loan from the authorities of the other institutions listed below, to whom our thanks are due.

The following abbreviations used in the enumeration of the specimens indicate the herbaria in which this material is deposited, etc. :—

A = Albany Museum, Grahamstown.

Am = Herbarium of the East African Agricultural Research Station, Amani.

- Be = Botanisches Museum, Berlin-Dahlem.  
 BH = Bolus Herbarium, Kirstenbosch.  
 BM = British Museum (Natural History), London.  
 Bx = Herbier du Jardin Botanique de l'État, Bruxelles.  
 E = Herbarium of F. Eyles, Salisbury, S. Rhodesia.  
 K = Royal Botanic Gardens, Kew.  
 M = MacGregor Museum, Kimberley.  
 N = Natal Herbarium, Durban.  
 NH = National Herbarium, Pretoria.  
 O = University Herbarium, Oxford.  
 P = Muséum National d'Histoire Naturelle, Paris.  
 S = South African Museum, Cape Town.  
 St = University Herbarium, Stellenbosch.  
 T = Transvaal Museum, Pretoria.  
 U = Universitetets Botaniska Museet, Uppsala.  
 V = Naturhistorisches Museum, Wien.  
 Z = Botanisches Museum, Universität, Zurich.  
 fl. = flowering.  
 s.n. = Sine numero.

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### CONCEPTION AND AFFINITIES OF

#### AMMOCHARIS *Herb. emend. Milne-Redhead & Schweickhardt.*

The similarity of a species of *Crinum* (subgenus *Stenaster*) to the genus *Ammocharis* was first recognized by Baker, who described a species from the Sudan under the name *C. ammocharoides* stating that the 'leaves closely resemble those of *Nerine* (*Ammocharis*) *falcata* and its variety *coranica*'. A living plant grown at Kew, which had been named *Crinum ammocharoides*, was observed by us to exhibit a leaf-arrangement practically indistinguishable from that of *Ammocharis coranica*, and one very different from that of any other species of *Crinum* known to us. A careful examination of the Tropical African herbarium material of *Crinum* at Kew revealed that several other species

placed in *Crinum* were readily separable from that genus on the basis of the shape and arrangement of the leaves.

These species possess leaves which are strap-shaped, somewhat falcate, always without an undulate margin, and not sheathing at the base: the specimens rarely showed the presence of a complete apex: all the leaves except the innermost (youngest) pair had cast off their apical portion by an absciss-layer, and in consequence appeared to be truncate. In some specimens the distichous biflabellate arrangement of the leaves had been preserved; in other cases this character was mentioned by the collectors\*. Further examination of these species showed that the flowers, except for the length of the perianth-tube, resembled those of *Ammocharis coranica* sufficiently closely to justify their transference to *Ammocharis*.

As a result of observations of botanists in the field and of examination by us of a number of plants in cultivation, we have learnt that the leaves of *Crinum Tinneanum*, *C. heterostylum*, and *C. angolense* die back to the top of the bulb at the end of a period of growth, and that their bases grow out again to form new leaf-blades during the next period of growth. This may happen to the same leaf a number of times, and the final length of the leaf depends on the duration of the growth-period. Normally the oldest pair of leaves fails to grow out again and in its stead a new (young) pair of leaves with intact apices develops†.

This method of growth is the same as in *Ammocharis coranica* and *Cybisetes longifolia*.

Whilst this remarkable behaviour has not yet been observed in *Crinum Baumii*, there is very little doubt that it does occur in this species. It is consequently transferred, together with *C. Tinneanum*, *C. heterostylum*, and *C. angolense*, to *Ammocharis*, the description of which is slightly emended in order to cover them.

Bentham and Hooker completely ignored Herbert's statement that the leaves perished in winter but the same ones sprouted again in the spring. Subsequent authors likewise ignored this fact, and relied on unimportant characters such as the relative length of the pedicel and perianth-tube to distinguish *Ammocharis* from *Crinum*.

The monotypic genus *Stenolirion* Baker, known only from the type gathering, is here reduced to *Ammocharis*. For details the reader is referred to the remarks under *A. Tinneana* (p. 183).

\* In species of *Crinum* the leaf-arrangement usually is not distichous. In the few species where it is distichous, the leaves are strongly sheathing at the base, never biflabellately arranged, they decrease rapidly in size upwards (the lowermost leaves are many times wider than the uppermost youngest leaves) and are usually concave above with strongly undulate margins.

† This character has recently been observed in the field to occur in certain species of *Crinum* (subgenus *Stenaster*) found in Northern Rhodesia, species which are easily distinguished from *Ammocharis* by their spiral leaf arrangement, by their sheathing leaf-bases, and by their flowers.

*AMMOCHARIS* Herb. emend. Milne-Redhead et Schweickhardt.

'*Amaryllis* Linn.' sec. Herb. App. p. 5 (1821), pro parte. *Ammocharis* Herb. App. p. 17 (1821), pro parte; & in Bot. Mag. LII, sub t. 2578 (1825); & *Amaryll.* pp. 77, 241 (1837); Roem. *Amaryll.* p. 61 (1847); Kunth, Enum. v, p. 611 (1850); T. Moore in Lindl. & Moore, Treas. Bot. I, p. 51 (1866); Harv. Gen. S. Afr. Pl. ed. 2, p. 382 (1868); Benth & Hook. f. Gen. Pl. III, p. 727 (1883); Baker, *Amaryll.* p. 96 (1888); Pax in Engl. & Prantl, Pflanzenfam. II, 5, p. 108 (1888); Baill. Hist. Pl. XIII, p. 48 (1894); Baker in Dyer, Fl. Cap. VI, pp. 172, 203 (1896); & in Dyer, Fl. Trop. Afr. VII, pp. 377, 404 (1898); Medley Wood, Handb. Fl. Natal, p. 132 (1907); Engl. Pflanzenw. Afr. IX, 2, pp. 344, 350 (1908); Thonner, Blütenpfl. Afr. p. 146 (1908); Bailey, Stand. Cyclop. Hort. I, p. 274 (1914); Marloth, Flow. S. Afr. IV, p. 115 (1915); Thonner, Flow. Pl. Afr. p. 138 (1915); Bews, Fl. Natal & Zulul. pp. 64, 65 (1921); Phillips, Gen. S. Afr. Flow. Pl. pp. 160, 163 (1926); Pax & Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, p. 409 (1930); Baker in Yearb. Am. *Amaryll.* Soc. I, p. 32 (1934); Hutch. Fam. Flow. Pl. II, p. 134 (1934), & in Yearb. Am. *Amaryll.* Soc. II, p. 78 (1935); Traub in Herbertia, v, pp. 111, 113 (1938); omnes (Medley Wood et Bews exceptis) pro parte. *Brunsvigia* Heist. sect. *Ammocharis* (Herb.) Schult. Syst. Veg. VII, p. 850 (1830); Endl. Gen. Pl. p. 177 (1836); Meissn. Gen. Pl. Vasc. p. 394 (1842 teste Pfeiffer); omnes pro parte. *Brunsvigia* Heist. subgen. *Ammocharis* (Herb.) Spach, Hist. Nat. Veg. XII, p. 423 (1846). *Palinetes* Salish. Gen. p. 116 (1866), pro parte, nomen illegit. '*Nerine* Herb.' sec. Baker in Journ. Bot. XVI, pp. 163, 167 (1878), pro parte, non Herb. '*Crinum* Linn.' sec. Baker in Journ. Bot. XVI, pp. 164, 168 (1878), non Linn.; & in Gard. Chron. n. ser. XV, p. 763 (1881); Benth. & Hook. f. Gen. Pl. III, p. 726 (1883); Baker, *Amaryll.* p. 74 (1888); Pax in Engl. & Prantl, Pflanzenfam. II, 5, p. 108 (1888); Engl. Pflanzenw. Ost-Afr. C, p. 145 (1895); Baker in Dyer, Fl. Trop. Afr. VII, pp. 377, 393 (1898); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, p. 409 (1930). omnes pro parte. *Stenolirion* Baker in Hook. Ic. Pl. XXV, t. 2493 (1896); & in Dyer, Fl. Trop. Afr. VII, pp. 376, 385 (1898); Engl. Pflanzenw. Afr. IX, 2, p. 351 (1908); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, pp. 398, 410 (1930); Hutch. Fam. Flow. Pl. II, p. 134 (1934), & in Yearb. Am. *Amaryll.* Soc. II, p. 78 (1936); Traub in Herbertia, v, pp. 111, 113 (1938).

*Bulbus* sphaerico-ovoideus, tunicatus, saepe superne conspicue attenuatus. *Folia* falcato-ligulata usque linearia, 1-3 juniora apice incolumbia rotundata, vestustiora apice semper manca et truncata, disticha, biflabellatim disposita, plerumque patentia vel solo adpressa, usque ad apicem bulbi sub finem cujusque temporis incrementi marcescentia, basibus corundem foliorum proximo tempore ita recrescentibus ut folia nova efficiant, probabiliter per compluria tempora incrementi persistentibus; margines plerumque scariosi, conspicue erosi. *Scapus* lateralis, compressus, solidus. *Umbella* 1- $\infty$ -flora. *Spathae* valvae 2, persistentes, papyraceae. *Bractae* filiformes, apicem versus plerumque ampliatae, persistentes. *Pedicelli* plus minusve teretes, longitudine varii,



sub fructu nec elongati nec inferiores deflexi. *Flores* actinomorphi. *Perianthii tubus* cum pedicello rectilinearis (nec angulum efformans), anguste cylindricus, plerumque obtuse angulatus, ore plus minus ampliatus. *Perianthii lobi* aequales, vel interiores paullo breviores et angustiores, perianthii tubo plerumque multo breviores rarius longiores, patentes, recurvi vel apicem versus spiraliter revoluti, anguste oblanceolati, obtusiusculi, exteriores valde cucullati, obtuse carinati, rubri vel albi, colore pro aetate vario. *Stamina* e perianthii tubo leviter vel valde exserta, ori vel prope os tubi affixa; filamenta filiformia, recta vel plus minus sursum curvata, subaequalia vel interiora longiora, actinomorphicè disposita, erecta vel plus minus divergentia, *numquam declinata*, alba usque rubra; antherae lineari-oblongae, rectae vel curvatae, dorsifixae, connectivi medio vel bene infra medium affixae, plus minus versatiles, luteae vel pallidae; pollen flavum. *Ovarium* obtuse angulatum; ovula 4–30 pro loculo, biseriatim disposita, per totum latus placentae affixa. *Stylus* filiformis, inclusus vel bene exsertus, interdum longitudine pro aetate varius, rectus vel tandem plus minus curvatus, colore filamentorum. *Stigma* integrum, minute 3-sulcatum, papillosum. *Capsula* indehiscens, membranacea, subglobosa, demum irregulariter rupta; pericarpium haud valde nervosum, demum a pedicello omnino secedens. *Semina* carnosae, pallide viridia, subglobosa vel obtuse angulata, saepe in capsula germinantia; embryo recta; endospermium copiosum.

*Artificial key to the species of Ammocharis.*

- Pedicels as long as, or longer than the perianth-tube; apex of the perianth-lobes spirally recurved . . . . . 1. *coranica*.  
 Pedicels very short, or up to half the length of the perianth-tube :  
   Leaves lorate, at least 5 mm. wide; flowers never solitary :  
     Apex of perianth-lobes spirally recurved in full anthesis: filaments 4 cm. long or more; style at length as long as, or longer than the perianth-lobes . . . . . 2. *Tinneana*.  
     Perianth-lobes curving outwards but never spirally recurved at the apex; filaments less than 2 cm. long; style less than half the length of the perianth-lobes :  
       Perianth-lobes lanceolate, 3–4 times as long as broad; style included . . . . . 3. *heterostyla*.  
       Perianth-lobes linear-oblong, tapering slightly towards both the apex and the base, about 6–12 times as long as broad . . . . . 4. *angolensis*.  
   Leaves linear, up to 4 mm. wide but usually much narrower (1 mm.); flowers solitary . . . . . 5. *Baumii*.

1. AMMOCHARIS CORANICA (*Ker-Gawl.*) *Herb. App.* p. 17 (1821); Roem. Amaryll. p. 62 (1847); *Plantae Zeyherianae* in *Linnaea*, xx, 4, p. 232 (1847) [*sphalm. coracina*]; Kunth, *Enum.* v, p. 613 (1850); Benth. & Hook. f. *Gen. Pl.* III, p. 727 (1883); Pax in *Engl. & Prantl, Pflanzenfam.* II, 5, p. 108 (1888) [*sphalm. coracanica*]; Phillips in *Flow. Pl. S. Afr.* t. 230 (1926) sub.nom. *Buphane disticha* *Herb.*, quoad ic.; & t. 712 (1938); Bremekamp in *Ber. Deutsch. Bot. Ges.* LV, p. 412, t. xi (1937).

*Amaryllis coranica* Ker-Gawl. in Bot. Reg. t. 139 (1816) & Quart. Journ. Sc. II, p. 361 (1817); Herb. sub. Bot. Mag. XLVII, t. 2113 (1820); Steud. Nomencl. II, p. 36 (1821) [sphalm. *coracina*]; Spreng. Syst. II, p. 52 (1825); Geel, Sert. Bot. Cl. p. 6 (1832); Reichb. Fl. Exot. III, p. 37, tab. 196 (1835); Dietr. Syn. Pl. II, p. 1181 (1840) [sphalm. *coracina*]. '*Haemanthus falcatus* (Jacq.) Thunb.' sec. Thunb. Fl. Cap. II, p. 255 (1918) & Fl. Cap. ed. Schult. p. 297 (1823) pro parte, non Thunb. Prodr. p. 58 (1794). *Brunsvigia coranica* (Ker-Gawl.) Herb. in Trans. Hort. Soc. IV, p. 181 (published between 29 Jan. and end of Febr. 1821); Sweet, Hort. Brit. ed. 1, p. 404 (1827); Schult. Syst. Veg. VII, p. 850 (1830). *Amaryllis coranica* Ker-Gawl. var. *pallida* Lindl. in Bot. Reg. XV, t. 1219 (1829). *Ammocharis coranica* (Ker-Gawl.) Herb. var. *pallida* (Lindl.) Herb. Amaryll. p. 241 (1837). *Brunsvigia uitenhagensis* Eckl. in Linnaea, XX, p. 232 (1847), nomen tantum. '*Ammocharis falcata* (Jacq.) Herb.' sec. Baker, Handb. Amaryll. p. 96 (1888); Dur. & Schinz, Consp. Fl. Afr. V, p. 253 (1893); Baker in Dyer, Fl. Cap. VI, p. 204 (1896); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, XV A, p. 409 (1930); Haggag in Gard. Chron. ser. 3, XCIII, p. 132 (1933), omnes pro parte, non (Jacq.) Herb.; sec. Medley Wood, Handb. Fl. Natal, p. 132 (1907) & in Trans. S. Afr. Phil. Soc. XVIII, p. 236 (1908); Eyles in Trans. Roy. Soc. S. Afr. V, p. 327 (1916); Schönl. Bot. Survey S. Afr. Mem. I, p. 36 (1919); Bews, Fl. Natal & Zulul. p. 65 (1921); Galpin, Bot. Survey S. Afr. Mem. XII, pp. 48, 63 (1927); Obermeijer in Ann. Transv. Mus. XVII, p. 195 (1937), omnes non (Jacq.) Herb. *Ammocharis coccinea* Pax in Engl. Bot. Jahrb. X, p. 3 (1888); Dur. & Schinz, Consp. Fl. Afr. V, p. 253 (1893); Burt Davy & Pott in Ann. Transv. Mus. III, p. 136 (1912); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, XV A, p. 409 (1930). *Ammocharis Taveliana* Schinz in Verh. Bot. Ver. Brandenb. XXXI, p. 214 (1890), quoad inflorescentiam; Dur. & Schinz, Consp. Fl. Afr. V, p. 253 (1893); Schinz in Bull. Herb. Boiss. IV, app. 3, p. 48 (1896); Baker in Dyer, Fl. Trop. Afr. VII, p. 404 (1898); Dinter in Fedde, Repert. XV, p. 86 (1919); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, XV A, p. 409 (1930); Range in Fedde, Repert. XXXIII, p. 21 (1933) [sphalm. *Taveliana*]. '*Crinum falcatum* Jacq.' sec. Fritsch in Bull. Herb. Boiss. ser. 2, I, p. 1107 (1901), non Jacq. *Crinum coccineum* (Pax) Fritsch in Bull. Herb. Boiss. ser. 2, I, p. 1108 (1901). *Crinum Tavelianum* (Schinz) Fritsch in Bull. Herb. Boiss. ser. 2, I, p. 1108 (1901), pro parte.

*Bulb* ovoid, up to 16 cm. in diameter (20 cm. fide Mogg), up to 25 cm. long including the 5 cm. long neck, tunicated; outer tunics firmly chartaceous, brown, dry, striate, shiny, glabrous, and smooth. *Leaves* up to 15, but often fewer, biflabellately spreading, strap-shaped, often falcate, extremely variable in length and width, 0.5–7.5 cm. wide, 2.5–115 cm. long, striate, glabrous, smooth, green or sometimes glaucous, margins scarious and minutely erose. *Scape* 6–35 cm. long, ancipitous, glabrous, smooth, erect, spreading and at length ascending. *Umbel* 3–56-flowered. *Spathe-valves* 3.5–8.5 cm. long, 1.2–3.0 cm. wide at the base, narrowly lanceolate to lanceolate, acute, papery,

conspicuously nerved; bracts filiform, obtuse, usually widened at the apex. *Pedicels* 0.6–6 cm. long. *Perianth* varying from pink to pinkish copper-brown or carmine, at times with a median white line on the inner and the outer surface of the tepals, shiny, sweetly scented; tube cylindrical, very variable in length, 0.8–2.5 cm. long; lobes oblanceolate, obtuse, 2.8–5.5 cm. long, about 0.5 cm. wide, gradually spreading from the base and spirally recurved towards the apex. *Stamens* more or less erect, slightly spreading, much exserted from the tube; filaments filiform, 3–4½ cm. long, carmine; anthers 5–7 mm. long, strongly curved. *Ovary* about 6–12 mm. long, cylindric or barrel-shaped, slightly wider than the pedicel and the perianth-tube; ovules 6–29 per loculus; style filiform, carmine, exserted 3.5–5.5 cm. beyond the perianth-tube. *Fruit* subglobose, about 2.5 cm. in diameter. *Seeds* subglobose or somewhat bluntly angled by pressure, up to about 1.5 cm. in diameter, often germinating while still enclosed in the fruit.

ANGOLA. Huilla Distr., Kihita, leg. *Antunes*, comm. *Dekindt* (V):—Muti-navakai and equally common at Mukuma.

SOUTHERN RHODESIA. Bulawayo, *Chubb* 7 (BM).

SOUTH-WEST AFRICA. Grootfontein Distr. Etosha Saltpan, Klein Namutoni, fl. Jan. 1919, *Breyer* in T.M. 20608 (T). Without definite locality, north-east of Grootfontein, fl. Nov. 1931, *Miss O. Bär* in T.M. 30291 (T). Tsumeb, leg. *H. Herre* cult. Stellenbosch, no. 3071 (BH). Otavi near Waterberg, fl. 17 Dec. 1892, *Dove* s.n. (Z). Otavi, fl. 1 Jan. 1925, *Dinter* 5273 (NH), fl. 2 Jan. 1925, *Dinter* 5280 (BH, Z). Between Gobabis and Sandfontein, in dried-up pan, fl. Nov. 1921, *Wilman* 1603 (BH, M). Gobabis Distr. Owinawa-Naua [S. of Aizeb River], 1300–1400 m., 23 Feb. 1911, *Seiner* 163 (Be):—on thin grey sand over limestone, flowers in great quantities, white eventually turning red. Karibib Distr. Between Khoiami and Onanis Rivers, fl. 7 Febr. 1885, *Belck* 48 a (comm. C. Rensch) (Be). Bethanie Distr. Bethanie, fl. Jan. 1885, *Schinz* 16, pro parte (Be, Z). Road to Bethanie, 1200 m., Feb. 1907, *Range* 221 (Be):—leaves fleshy, about 20 cm. long and about 2 cm. wide, flowers purple. Kuibis, in clayey river-soil, 1300 m., Feb. 1909, *Range* 634 (Be):—large bulb, thick fleshy leaf-rosette, scape 50 cm. high, red-flowered. Lüderitz Distr. Aus, cult. Kirstenbosch, fl. 28 Dec. 1936, *Erni* in Nat. Bot. Gard. 104/30 (BH, K, NH):—flowers old rose.

BECHUANALAND PROTECTORATE. Bakhatla Reserve, Mochudi, *Pillans* in Bolus Herb. 21375 (BH):—flowered in Mr. Pillans' garden, March 1915. Lobatsi Block, Lobatsi, fl. March 1914, *Rogers* 6742 (A, Z).

CAPE PROVINCE. Mafeking Distr. Setlagoli, *Lamb* (Nat. Bot. Gard. 243/26) (BH):—flowered Jan. 1930 and 1932. Vryburg Distr. Klipfontein, fl. 26–29 Dec. 1812, *Burchell* 2638 (K, type gathering?). Kuruman Distr. Between Kuruman and Kosifontein, fl. 20 Dec. 1812, *Burchell* 2532 (K). Barkly West Distr. Greef Puts, fl. Jan. 1921, *Wilman* s.n. (K). Asbestos Mountains, fl. Dec. 1884, *Marloth* 2080 (NH, St). Prieska Distr. Prieska, flowers and leaves,

26 Jan. 1931, addit. leaves Dec. 1934, *Bryant* 563 (K) :—leaves showing bilateral and plaited arrangement, much eaten by animals at the tips, inflorescence lateral. Kimberley Distr. In sandy soil near Kimberley, 1150 m., fl. Dec. 1885, *Marloth* 784 (Be, BH, NH). Dronfield, in grass-veld, fl. Dec. 1919, *Sutton* 89 (M). Karreeboom, along Boshof-roadside, fl. Jan. 1923, *Wilman* 2243 (BH, M). Albert Distr. Near the Orange River, fl. December, *Burke* s.n. (K, V). Aliwal North Distr. Plains near Aliwal North, Nov. 1894, *Galpin* (leg. J. Wood) 1894 (NH) :—flowers pink, very sweetly scented. Cradock Distr. Mortimer,  $\pm$  780 m., fl. Jan. 1902, *Bolus* (leg. Kensit) 9319 (BH). Beaufort West Distr. Nieuwveld Mts. near Beaufort West, 900–1500 m., *Drège* 8543 (K, V). Oudtshoorn Distr. Oudtshoorn, fl. March 1909, *Britten* 9 (A) & fl. Jan. 1916, *Taylor* s.n. (A). Somerset East Distr. In shade at the foot of the Boschberg, 850 m., fl. Dec. *Mac Owan* 1815 (K) :—leaves below the inflorescence always erose at the apex, the youngest leaf only has an intact apex during the month of May. In the veld near Somerset East, 850 m., fl. Nov.–Jan., *Mac Owan* 1850 (A, BM, K, Z) :—‘the tips and often the upper half of the leaves . . . rot away upon the damp ground before the flowering season’. Fl. 13 Jan. 1900, *R. W. Rogers* s.n. (A). Graaff Reinet Distr. In plains, grass or karroo near Graaff Reinet to Somerset etc., 750 m., fl. Nov. 1871, *Bolus* 810 (BH). Humansdorp Distr. Between bushes near the Couga River, fl. Dec. 1872, *Mac Owan* 1850 (K). Clarkson, *Kitching* s.n. (K). Without precise locality, fl. Feb. 1848, *A. Prior* (K). Uitenhage, Magennis Park, cult. Kirstenbosch, fl. 29 Jan. 1937, *Cartwright* in Nat. Bot. Gard. 484/28 (BH, K). Albany Distr. Fish River, fl. Dec. 1906, *White* s.n. (A). Near Botha's Hill, fl. Jan. 1924, *Rogers* 27593 (Z). Brakkloof, fl. Jan. 1900, *White* s.n. (A). Trappes Valley, fl. Jan. 1932, *Holland* in *Bolus* Herb. 21377 (BH). Near Grahamstown, fl. Dec. 1933–Jan. 1934, *Britten* in *Bolus* Herb. 21374 (BH) :—in dry places, e.g. open parts of the Fish River Scrub. Bedford Distr. Karroid veld on road from Grahamstown, fl. Jan. 1930, *Dyer* 2323 (A) :—common in small area, flowers pale pink. Near Bedford on flat dry veld, fl. Jan. 1930, *Ryder* 112 (K). Queenstown Distr. Junction farm, Gwatyn, in damp grassy hollows on banks of Zwart Kei River, 700 m., fl. 18 Nov. 1911, *Galpin* 8252 (A, NH). Cathcart Distr. Blesbokflats near Windvogel Mountain, 900 m., fl. Nov. *Drège* 8544 (K, V). Between Windvogel Mountain and Zwart Kei River, 900–1200 m., fl. Feb., *Zeyher* (A, Be, K, V, Z). Komgha Distr. Near Komgha, in the valley of the Kei River, 540 m., fl. Dec. 1891, *Flanagan* 1073 (A, BH, NH).

NATAL PROVINCE. Umgeni Distr. Thornville, Nov. 1931, *Rump* in Natal Herb. 22023 (N) :—flowers pink and white. Pietermaritzburg, 600–900 m., fl. Sept.–Oct. 1858, *Sutherland* s.n. (K). Between Pietermaritzburg & Greytown, Feb. 1895, *Medley Wood* 7102 (N) :—flowers pink. Without locality, fl. Oct. 1937, *Smith* s.n. (NH) :—plant covering the whole farmyard and forms the principal green grazing for cattle and horses at this time of the year when, owing to the prolonged drought, very little green grass is available. Weenen

Distr. Weenen country, Mooi River Valley, 600–900 m., fl. Oct. 1858, *Sutherland* s.n. (K). Stendal, 250–750 m., Nov.–Dec. 1913, *Thode* in Herb. Stellenbosch 2504 (St) :—flowers deep rose-red, leaves (in all specimens seen) browsed at the tips.

BASUTOLAND. Mafeteng Distr. Hermon, *Dieterlen* 512 (K, NH) :—flowers dark crimson.

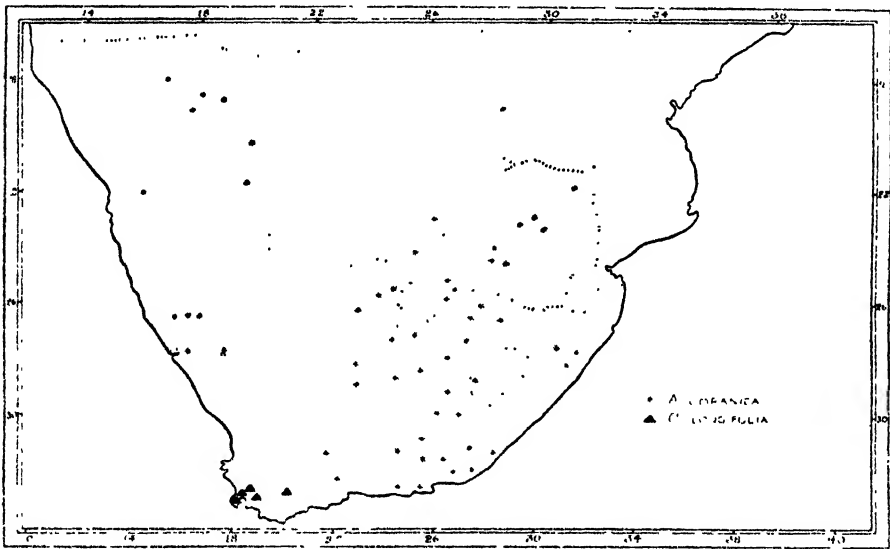
ORANGE FREE STATE. Without precise locality, Caledon River, Jan. *Burke* (K), *Zeyher* (V). Fauresmith Distr. Fauresmith, Nov. 1931, *Verdoorn* 1063 (NH). Near Luckhoff, in soft sandy soil, 1400 m., fl. Jan. 1928, *Smith* 5310, pro parte (NH). Bloemfontein Distr. Without locality, 1300 m., Nov. 1915, *Potts* 2038 (BH) :—flowers pink to red, leaves 12–14 per plant, arranged on two sides of the bulb . . . and lie along the ground. Kroonstad Distr. Kroonstad, near Vals River, fl. Oct. 1928, *Pont* 371 (NH, Z). Nov. 1928, *Miss M. Egan* 13 (NH). Vredefort Distr. Lion River Stn. (Leeuwspuit or Leeuwstroom), *Barrett Hamilton* s.n. (BM). Bethlehem Distr. Reitz, cult. Kirstenbosch, fl. 9 Dec. 1932, *Miss M. Basson* in Nat. Bot. Gard. 527/29 (BH). Boshof Distr. Smitskraal, fl. 30 Nov. 1911, *Burt Davy* 11318 & 11336 (NH). Winburg Distr. Winburg, leg. *Herre*, cult. Stellenbosch no. 3675 (BH, K) :—flowered Dec. 1936.

TRANSVAAL PROVINCE. Wolmaransstad Distr. Maquassi, cult. Kirstenbosch, fl. 26 Nov. 1933, *Broom* in Nat. Bot. Gard. 2632/33 (BH). Potchefstroom Distr. Potchefstroom, fl. 1 Nov. 1908, *Acheson* in T.M. 6233 (T). Ventersdorp, Goedgedacht, 13 Dec. 1932, *Sutton* 704 (NH) :—flowers pink, limbs of perianth longer than the tube, leaves radical, prostrate, spreading like a spider. Johannesburg Distr. Vereeniging, fl. 29 Oct. 1911, *Leslie* in T.M. 10901 (T). Pretoria Distr. 'The Willows', near Pretoria, fl. Nov. 1906, *Mundy* in Govt. Herb. 4630 (NH). Beestekraal, fl. Dec. 1908, *Jenkins* in T.M. 7123 (T). Brits, in dolomite valley at Welgevonden, 960 m., 8 Dec. 1934, *Mogg* 14637 (NH) :—leaves . . . lying flat on ground, flowers deep red. Farm Roodekopjes, on granite kopje, 1040 m., 15 Oct. 1935, *Marais* in Nat. Herb. 20248 (NH) :—flower sickly sweet honeysuckle-scented ; colour appears to vary in same plant, one year dark and another light pink to reddish-maroon ; leaves have come and died off about four times in a summer. Waterberg Distr. Warmbaths, fl. 30 Sept. 1908, *Leendertz* 1379 (T). On farm 'Doddington', 31 Oct. 1936, *Galpin* 13894 (K, NH) :—bears 2–3 peduncles appearing in quick succession ; flowers rose-madder. Naboomspruit, sand veld plains on farm Weltevreden, *Galpin* M 663 (NH), & fl. 23 Nov. 1931, *Galpin* 11575 (NH, BH). Mosdene, farm Roodepoort, 8 Oct. 1925, *Galpin* M 759 (NH, Z) :—flowers wine-red. Ypres siding, on sand veld plains, 18 Nov. 1932, *Galpin* 11807 (NH, Be, BH, K, V) :—flowers bright brownish-pink. Pietersburg Distr. Chuniespoort, fl. Oct. 1935, *Obermeijer* in T.M. 34682 (K, T). Lydenburg Distr. Sekukuni, 24 Oct. 1934, *Barnard* 109 (NH) :—grows along old river beds and in old lands, and bears a head of beautiful red flowers ; the Swazi people take the outer tunics of the bulb and burn them in flames which are extinguished as soon as the tunics are

half burnt ; this charred material is then chewed until a kind of pitch is formed ; this pitch is then stuck together to form the headrings (Imbote) of the Swazi chiefs and headmen ; the whole male population goes into the veld to make these rings in one day with great ceremonial\*. Zoutpansberg Distr. Punda Maria, Krüger National Park, fl. 20 Oct. 1932, *Lang* in T.M. 32277 (T).

CULTIVATED : Kimberley Gardens, fl. Nov. 1936, *Wilman* s.n. (M, K) :—common in Kimberley district in red sand. Stellenbosch 8995 (St), 6 Nov. 1928 from Steenskloof, Winburg, O. F. S. :—flowers lake-red, perianth segments curled back, umbel 24-flowered, peduncle flattened. Fulham, fl. 15 July 1821, *Burchell* s.n. (K).

Without locality : *Burke & Zeyher* 1652 (O). *Thunberg* (U).



Distribution of *Ammocharis coranica* (Ker-Gawl.) Herb. and of *Cybustetes*. One locality of *A. coranica* in southern Angola is just beyond the limits of the map.

The earliest record of this species having been collected and preserved as a herbarium specimen is that of Thunberg, who gathered it at the Cape (probably in the south-eastern parts of the province, at some time during the years 1772–1775). He finally misidentified this plant as *Haemanthus falcatus* (Jacq.) Thunb., although, judging by his comment '*falcatus*? nov.?' on the sheet, he at one time had wondered whether it did not represent a new species. It is, however, definitely *A. coranica* (Ker-Gawl.) Herb. The specimen has the biflabellate leaf-arrangement, and spirally recurved perianth-segments, the latter being a character never present in *Crinum falcatum* Jacq.

\* A further note on the uses of the bulbs has been received from Miss A. A. Obermeijer, who writes : ' the natives of NE. Transvaal remove the tunics and heat the bulbs until they change into a sticky tarry mass which, when cold, turns into a black cake. The cake is used for water-proofing earthenware.'

*A. coranica* was first described, under *Amaryllis*, by Ker-Gawler in the 'Botanical Register' from a specimen collected by Burchell. This account is of particular interest because of the valuable field-notes supplied by the collector, and of Ker-Gawler's remarks concerning the differences between this plant and *Brunsvigia falcata*.

Lindley (1829) described *Amaryllis coranica* Ker-Gawl. var. *pallida*, which Herbert later (1837) correctly transferred to his genus *Ammocharis*. In our opinion the 'varietal' characters enumerated by Lindley are of no taxonomic value: the paler colour, smaller flowers, and less glaucous leaves of the plant figured were most probably due to the unfavourable conditions under which it had been grown.

In 1888 Pax described a new species, *A. coccinea*, without mentioning a word as to how it differed from its allies. This was the more regrettable since the plant upon which he based his description was collected by Marloth in the same area not very far from Burchell's original locality of *A. coranica*. Pax's species agrees in every detail with Burchell's plant, and we have no doubt whatsoever in regarding it conspecific with *A. coranica*.

Schinz, in 1890, described *A. Taveliana*, which he said differed from its allies mainly in its leaves. Examination of the type-specimen in the Zürich Herbarium, and of the type number in the Berlin Herbarium, has proved that, whereas the inflorescence is typically that of *A. coranica*, the leaves and bulb-scales undoubtedly belong to a species of *Boöphone*, most probably *B. disticha* (Linn. f.) Herb. Schinz's remarks with regard to the leaves and bulb-scales (examined by von Tavel) thus apply only to the *Boöphone*. *A. Taveliana* is a mixture of two distinct genera, and owing to the fact that a part of the type as well as the whole of such specimens as Belck's no. 48a cited by Schinz under his species are nothing but typical *A. coranica*, Schinz's species in part has been placed in synonymy under *A. coranica*. Smith's no. 5310 in the National Herbarium, Pretoria, is rather interesting, as it also consists of a mixture of the same genera.

Baker, in 1888, caused confusion between *A. falcata* (Jacq.) Herb. and *A. coranica* (Ker-Gawl.) Herb. by treating them as conspecific, although a study of Jacquin's figure of the former and that of Ker-Gawler of the latter species mentioned above should have revealed the fact that they could on no account be considered to represent one and the same species. Later authors unfortunately have accepted Baker's views, and were consequently misled almost without exception. Even botanists of such high repute as Marloth failed to realize that *A. falcata* and *A. coranica* are two very different plants. For further details regarding the misinterpretation of this species the reader is referred to the exhaustive synonymy given above.

Attention should be drawn to a strange error in 'Flowering Plants of South Africa', tab. 230 (1926), published under the name '*Buphane disticha*'. The plate represents *A. coranica*, whereas the accompanying text refers to *B. disticha*. This mixture has already been pointed out by R. A. Dyer in 'Herbertia',

III, p. 38 (1936), who unfortunately misidentified the plate with *Ammocharis falcata* (Jacq.) Herb. A second portrait appears on tab. 712 of this work, this time under the correct name. This figure is of interest as it shows a plant with as many as ten leaves with entire apices, though this may be due to the artist having made the mistake of completing the apparently damaged leaves, an error similar to that which was made by Hermann's artist in 1698.

In both vegetative and floral characters *A. coranica* is extremely variable.

The number and width of the leaves depends largely on the age and vigour of the bulb, whereas their length is dependent on the length of time the bulb has been in active growth.

Similarly the number of flowers per umbel is dependent on the age and vigour of the bulb. The colour of the flowers varies in intensity and to some extent is correlated with age. The diverse way in which the colour has been defined by collectors can be accounted for partly by the difference in colour-judgment of the individual.

The length of the perianth-tube is another variable character. In flowers taken from a herbarium sheet of a single gathering the variation was as from 0.8 to 2.0 cm. This figure is abnormally high, probably owing to the method of drying of the specimens concerned, although values from 0.8 to 1.6 cm. are not infrequent. This clearly indicates that the length of the perianth-tube as a taxonomic character is of value only beyond fairly wide limits.

Examination of a selection of specimens has shown that the number of ovules in each loculus is extremely variable: from 15 to 29 have been observed in a single gathering (Galpin's no. M 663), whereas in the type-specimen the number was as low as 6 ovules in a loculus. We have been unable to examine all the ovaries in any one umbel, a point which should be investigated when ample material becomes available.

The geographical distribution of this species is fairly wide in southern Africa, reaching Southern Rhodesia and the southern parts of Angola; it appears to be entirely absent from the area of evergreen sclerophyllous bush as defined by Pole Evans (Bot. Surv. S. Afr. Mem. xv, p. 8: 1936), better known as the area of the Cape Flora.

The flowering period coincides with the period of summer rains, and is somewhat earlier (October–December) in the eastern parts of South Africa than in the western parts where the species flowers principally during December–January.

## 2. *AMMOCHARIS TINNEANA* (Kotschy et Peyritsch) Milne-Redhead et Schweickhardt, comb. nov.

*Crinum Tinneanum* Kotschy & Peyritsch, *Plantae Tinneanae*, p. 44 & tab. 21 (1867); Baker in Gard. Chron. xvi, p. 39 (1881); and Handb. Amaryll. p. 79 (1888); Dur. & Schinz, *Consp. Fl. Afr.* v, p. 251 (1893); Baker in Dyer, *Fl. Trop. Afr.* vii, p. 395 (1898); Brown & Massey, *Fl. Sud.* p. 391 (1929); De Wild. *Plant. contre la Lèpre*, p. 21 (1937). *Crinum ammocharoides* Baker in Journ.



Bot. xvi, p. 195 (1878); and in Gard. Chron. xvi, p. 39 (1881); and Handb. Amaryll. p. 79 (1888); Dur. & Schinz, Consp. Fl. Afr. v, p. 246 (1893); Höhnelt, Disc. Lakes Rud. Stef. II, p. 180 (1894), cum icon.; Baker in Dyer, Fl. Trop. Afr. vii, p. 397 (1898); Chevalier, Fl. l'Afr. Centr. I, p. 306 (1913); Broun & Massey, Fl. Sud. p. 391 (1929); Jex Blake in Yearb. Am. Amaryll. Soc. II, p. 52 (1935); De Wild. Plant. contre la Lèpre, p. 17 (1937). *Crinum Bainesii* Baker in Gard. Chron. xvi, p. 39 (1881); and Handb. Amaryll. p. 79 (1888); Dur. & Schinz, Consp. Fl. Afr. v, p. 247 (1893); Schinz in Bull. Herb. Boiss. IV, App. 3, p. 47 (1896); Baker in Dyer, Fl. Trop. Afr. vii, p. 394 (1898); Dinter in Fedde, Repert. xvi, p. 244 (1919); De Wild. Plant. contre la Lèpre, p. 17 (1937). *Crinum Thruppii* Baker in James, Unknown Horn of Africa, p. 322 (1888); and Handb. Amaryll. p. 79 (1888); Dur. & Schinz, Consp. Fl. Afr. v, p. 251 (1893); Rendle in Journ. Linn. Soc. Lond. Bot. xxxvii, p. 223 (1905); De Wild. Plant. contre la Lèpre, p. 21 (1937). *Crinum Lastii* Baker, Handb. Amaryll. p. 79 (1888); Dur. & Schinz, Consp. Fl. Afr. v, p. 249 (1893); Engl. Pflanzenw. Ost-Afr. C, p. 145 (1895); Baker in Dyer, Fl. Trop. Afr. vii, p. 395 (1898); De Wild. Plant. contre la Lèpre, p. 19 (1937). *Crinum rhodanthum* Baker in Dyer, Fl. Trop. Afr. vii, p. 397 (1898); Hook. f. in Bot. Mag. cxxvii, tab. 7777-8 (1901); Watson in Gard. Chron. ser. 3, xxxiii, p. 315 (1903); N.E. Brown in Bull. Misc. Inf. Kew. 1909, p. 143 (1909). *Stenolirion Elliotii* Baker in Hook. Ic. Pl. xxv, t. 2493 (1896); Baker in Dyer, Fl. Trop. Afr. vii, p. 385 (1898); Engl. Pflanzenw. Afr. ix, 2, p. 351 (1908); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, p. 410 (1930) [sphalm. *Elliottii*].

*Bulb* ovoid, up to 12 cm. in diameter, and 17 cm. long, including the 2-6 cm. long neck: outer tunics firmly chartaceous, dry, brown, striate, shiny, glabrous and smooth. *Leaves* up to 13, but often fewer, biflabellately spreading, strap-shaped, often falcate, extremely variable in length and width, 5.5-32 cm. long, 0.5-6.0 cm. wide, striate, glabrous, light green or sometimes glaucous; margins scarious and minutely erose. *Scape* 3.5-22.5 cm. long, compressed, glabrous, smooth, somewhat spreading. *Umbel* 4-30-flowered; spathe valves up to 6.5 cm. long, variable in length and width, narrowly lanceolate to lanceolate, acute, papery, conspicuously veined; bracts filiform, obtuse, widened towards the apex. *Pedicels* 0.2-4.5 cm. long. *Perianth* varying from a delicate pink to carmine or a dull purplish-red, each lobe usually with a white median line on the inner surface, shiny, sweetly scented; tube narrowly cylindrical, extremely variable in length, 6-13 cm. long; lobes narrowly oblanceolate, obtuse, 4.5-9 cm. long, about 0.5 cm. wide, gradually spreading from the base and spirally recurved towards the apex. *Stamens* more or less erect, slightly spreading, much exserted from the tube; filaments 4-7.5 cm. long, carmine; anthers 4-9 mm. long, strongly curved. *Ovary* about 1 cm. long, cylindrical or barrel-shaped, slightly wider than the pedicel and perianth-tube; ovules 8-29 per loculus; style carmine, exserted 5.5-7.5 cm. beyond the perianth-tube. *Fruit* subglobose, 2-2.5 cm. in diameter. *Seeds* subglobose, somewhat bluntly angled by pressure, up to 1 cm. in diameter.

**UBANGI-SHARI.** Ndele, on plateau at 650 m., fl. 20–30 April 1903, *Chevalier* 8202 (P). Ndouka and Kouti country, in cultivated ground at Saboum, fl. 3–12 May 1903, *Chevalier* 8394 (Be, P). Very common from Nyellim to Kom and from Kom to Oulgon, Ndamms' country, fl. 30 May 1903, *Chevalier* 8555 (Bx, P).

**ANGLO-EGYPTIAN SUDAN.** Bahr el Ghazal Province. Banks of Bahr el Ghazal towards Dembo and Bongo, 1863, *Tinné* 7 a (V, lectotype). Dembo, fl. April 1863, *de Heuglin* 12 (V). Seriba Ghattas, fl. 4 April 1869, 5 April 1869, 1 May 1871, *Schweinfurth* 1370 (K), 1787 (Be, K, type of *Crinum ammocharoides* Baker, N, Z), 208 (Be, K). Dem Zubeir to Wau route, fl. 22 March 1902, *Broun* (Gov. Herb. 540) (K). Wau, *Mrs. Macintosh* s.n. (K). In bare ironstone area, in crevice with some organic matter and sand, 40 miles south of Wau, 14 Feb. 1937, *Myers* 6300 (K) :—bulb deep; no leaves; flowers deep red. Kordofan Province. El Obeid, fl. July 1875 & Sept. 1875, *Pfund* 765 (K), 377 (K). El Obeid, *Pfund* 509 (Be), 510 (Be), s.n. (Z).

**ABYSSINIA.** East shore of Lake Rudolf, fl. March 1898, *Wellby* s.n. (K). River Webbe Shibeli SW. of Crocodile Camp, fl. 4 Sept. 1894, *Donaldson Smith* s.n. (BM). Gorgora, fl. 13 Sept. 1894, *Donaldson Smith* s.n. (BM). Gorgora—Gollaboda, among pebbles, 17 June 1900, *Ellenbeck* 1187 (Be) :—herb, 20–40 cm. high; leaves spreading densely on the ground; flowers pink. Ogaden, at Hahi, fl. April 1885, *James & Thrupp* s.n. (K, type of *Crinum Thruppii* Baker).

**UGANDA.** Escarpment at W. Madi, 840 m., March 1934, *Tothill* 2514 (K) :—leaves flat, spreading, often truncate; flowers deep rose-pink. Locally abundant among dry stones and baked soil at Okollo, West Nile Province, *Eggeling* 1971 (K) :—flowers pink, the head drooping under their weight. Kyere, Teso, near small rocky outcrop, 1080 m., March 1933, *Chandler* 1138 (K) :—leaves practically all dried-off; flowers very pale pink on opening, becoming very deep pink with age.

**KENYA COLONY.** On grassy stony slope at Kisumu, 1050 m., Feb. 1915, *Dummer* 1818 (BM, K) :—flowers pale rose. Plains beyond Lemek (?) Valley towards Amala River, fl. Nov. 1908, *Evans* 760 (K, N). Nairobi, fl. 3 March 1927, *Shantz* 117 b (K). Nairobi, in open grassland, 1770 m., *Napier* 48 (K) :—leaves appear before the flowers, like two plaits; flowers a delicate pink at first, fading to a dull purplish-red. Nairobi, 1700 m., 23 Feb. 1935, *Napier* 3630 (K) :—specimens showing differences in length of the petals, in no way connected with the age of the flower. Dry bush country at Makindi, 840 m., *Gardner*, Forestry Herb. 3015 (K) :—in flower just before the rains; flowers pinky-red. In grassland and open savannah forest at Emberre, Itabwa, 1140 m., 26 Sept. 1932, *M. D. Graham*, Agric. Herb. 2244 (K) :—peduncle erect; flowers bright pink. Without locality, *Mortimer* s.n. (K). Frequent in savannah between Taveta and the Bura Mountains, 600–700 m., 24–25 Oct. 1902, *Engler* 1909 (Be) :—inflorescences lateral, usually two; flowers carmine.

**TANGANYIKA TERRITORY.** Kikobe ferry, near R. Kagera, 30 March 1904, *Bagshawe* 173 (BM) :—herb; flower-tube pink; open petals cream. Kigoma

District, 1926, *Grant* s.n. (BM). Ussambiro, 22 Oct. 1890, *Stuhlmann* 852 (Be):—plants leafless; flowers red. Neuweid, Ukerewe, *Conrads* 1905 (Be). Usula-Usiha, fl. 20–31 Nov. [1885?], *Fischer* 595 (Be). Shinyanga, locally common on grey valley clay soils, 1140 m., 6 Nov. 1935, *Burt* 5307:—spectacular pink flowers opening in the evening; flowers appearing before the leaves. Manyoni District, common in shallow drainage valley among *Lannea humilis* and *Microchloa indica* at Kazikazi, 1200 m., 2 Dec. 1931, *Burt* 3538 (K):—spectacular pink flowers opening at night and lasting one night only, then withering to a red colour. Kilimatinde, in soil rich in salt by Balangidda Lake, 9 Dec. 1904, *von Prittwitz* 155 (Be):—flowers deep purple. Kondoa District, common on the Kikori Hills, 1260–1320 m., 9 Nov. 1929, *Burt* 2760 (K):—bulb 8–10 inches in diameter; flowers pink, appearing before leaves, pollinated by the hawk-moth, *Herse convolvuli*. In grassland at Geraragna near Kilimanjaro, Nov. 1909, *Endlich* 709 (Be):—flowers deep red. Kagum [Ngum] Mts., 160 km. inland from Zanzibar, *Last* s.n. (K, type of *Crinum Lastii* Baker):—bulb large, black; leaves disarticulating after the flowers have fallen: flowers a pretty pink colour. Common on red soil, Mkata Plain, 13 Jan. 1934, *Michelmores* 924 (Am, K):—only specimen seen in flower; seed abundant, very variable in size; flowers pink. Ukonge, in open places in savannah forest, 6 Oct. 1894, *Stuhlmann* 8647 (Be):—flowers dark pink. Uluguru foothills, in grassland, 350 m., 19 Sept. 1913, *von Brehmer* s.n. (Be):—flowers pink, faintly sweet-scented.

RUANDA-URUNDI. On hillsides, Urundi, 1200–1500 m., *Scott Elliot* 8175 (K, type of *Stenolirion Elliotii* Baker).

NORTHERN RHODESIA. In woodland at Ndola, Oct. 1906, *Allen* 346 (K, S):—flowers red. Mazabuka, 1200 m., 6 Dec. 1921, *Mrs. Woods* 3 (BM):—leaves in double fan; 8–12 flowers from thick spongy stem, pale pink, sweet-scented, especially at night. Common on heavy red soil at Mazabuka, 12 Nov. 1931, collector unknown (Central Research Station 512) (K):—herb 9–12 inches high; flowers pink with white stripes turning pink and finally brilliant scarlet on drying; fruit acorn-shaped, indented into three. Mission Road, Mumbwa, *Mrs. Macaulay* 962 (K):—flowers pale strawberry with a line up each segment. Without locality [probably Bombwe], *Martin* s.n. (K).

SOUTHERN RHODESIA. Cultivated at Salisbury, 18 Nov. 1935, *Eyles* 7370 B (E, K):—received as *Myres* 645 from Sabi River Valley, 450–600 m.; bulb 3–4 inches in diameter, with dry brown outer tunics; imperfect leaves 9–11; peduncle compressed, green, 4 inches long; pedicels 1 inch long: flowers 14 in umbel, pink to red, sweet scented; perianth-tube slightly curved, 3–4 inches; segments curled back, 2 inches long.

BECHUANALAND PROTECTORATE. Koobie [Kobe], Ngamiland, Oct.–Nov. 1861, *Baines* s.n. (K, type of *Crinum Bainesii* Baker):—leaves large and spreading, hugging the ground; flowers pink to carmine. Kwebe, Dec. 1896, *Lugard* 40 (K, type of *Crinum rhodanthum* Baker, A):—flowers red. Bushman Mine, Eastern Kalahari, fl. Oct. 1935, *Lang* in T.M. 24925 (T).

**SOUTH-WEST AFRICA.** Amboland, Olukonda, 1886, *Schinz* 522 (Z).

**CULTIVATED.** Royal Botanic Gardens, Kew. Fl. 12 July 1899, entry number 108/99, *Lugard*, from Ngamiland (type of Bot. Mag. tt. 7777-8) (K). Fl. 25 Sept. 1934, entry number 426/34, *Jex Blake*, probably from Kenya Colony (K). Entebbe Botanic Garden, Uganda, *Mahon* 2 (K) :—a native of Kavirondo, Kenya Colony ; leaves light green, sometimes slightly glaucous, sickle-shaped, 12-18 inches long, prostrate, with a sort of distichous arrangement ; stem very compressed, rigid, 9 inches long ; perianth segments, stamens and style a uniform rosy-purple, shining ; tube brownish-purple. Nairobi Arboretum, Kenya Colony. March 1937, *Gardner*, Forestry Herb. 3597 :—bulb from Turkana, Kenya Colony ; flowers white turning pink.

The original description of *A. Tinneana* was taken partly from the two sheets of Tinné's no. 7 a and partly from Kotschy's no. 392. The inflorescence shown on the plate is undoubtedly taken from Tinné's no. 7 a, whilst the spathe-valve shown on the same plate is taken from Kotschy's no. 392. The flowers and the dissections on the plate are probably taken from Tinné's no. 7 a, since in that specimen they are in a much better state of preservation than in Kotschy's material. Tinné's no. 7 a in the Vienna Herbarium is accordingly selected as the type of the specific name.

It will be noticed that several species of *Crinum* have been reduced to *A. Tinneana*. Five of these were described by Baker. The characters used by him to distinguish between them and *Crinum Tinneanum* in the 'Flora of Tropical Africa' are given below, letters and numbers being prefixed for purposes of reference.

- |  |                               |
|--|-------------------------------|
| [A] Segments $\frac{1}{2}$ as long as the perianth-tube :                  |                               |
| [B] Perianth-tube $2\frac{1}{2}$ -3 in. [6.4-7.6 cm.] long :               |                               |
| [D <sub>1</sub> ] Pedicels short .....                                     | 1. <i>C. Bainesii</i> .       |
| [D <sub>2</sub> ] Pedicels $\frac{3}{4}$ -1 in. [1.9-2.6 cm.] long .....   | 2. <i>C. Thruppii</i> .       |
| [D <sub>3</sub> ] Pedicels 1-2 in. [2.6-5.1 cm.] long .....                | 3. <i>C. Tinneanum</i> .      |
| [BB] Perianth-tube 3-4 in. [7.6-10.2 cm.] long :                           |                               |
| [D <sub>4</sub> ] Pedicels $\frac{1}{2}$ -1 in. [1.3-2.6 cm.] long ..      | 5. <i>C. Lastii</i> .         |
| [AA] Segments $\frac{2}{3}$ - $\frac{3}{4}$ as long as the perianth-tube : |                               |
| [C] Perianth-tube 3 in. [7.6 cm.] long .....                               | 14. <i>C. rhodanthum</i> .    |
| [CC] Perianth-tube 3-4 in. [7.6-10.2 cm.] long .....                       | 15. <i>C. ammocharoides</i> . |

Study of the abundant material cited above has shown that the distinctions drawn by Baker are illusory.

First, considering the relative length of perianth-segments to perianth-tube, it is found that this factor varies from 0.4 to 0.8, and if a sufficient number of specimens be examined practically any value for the factor between these limits can be found. The factor for the type-specimen of *C. Tinneanum* varies from 0.60 to 0.67, and this species would consequently fall into section [AA] of the above key, whereas Baker placed it in section [A]. The type-gathering of *Crinum ammocharoides* possesses the factor varying from 0.46 to 0.71 ;

accordingly, this gathering falls into both sections [A] and [AA] of the key, which is proof that this factor is unreliable and should not be used as a diagnostic character.

The next character used in the key, the length of the perianth-tube, is likewise unreliable. The type gathering of *Orinum ammocharoides* has tubes varying from  $2\frac{3}{4}$  to  $4\frac{1}{4}$  inches in length; consequently it would fall under both sections [B], [BB], [C], and [CC] of the key. *Kotschy* 392 from the Sudan has tubes  $2\frac{3}{4}$  to  $3\frac{3}{4}$  inches in length, and similarly would fall under any of the sections just mentioned.

Perianth-tubes of any length between 6 cm. and 13 cm. can be found, and we have not been successful in finding any correlation between this and any other character. There is, however, a tendency for the plants with long-tubed flowers to be more plentiful in the northern parts of the geographical area, whereas plants with short-tubed flowers predominate towards the south.

The length of the pedicels varies very considerably. Even in the flowers of a single umbel variations such as 0.8–3.0 cm. [Macaulay 962, Pfund 765], 0.2–1.8 cm. [Chandler 1138], and 1.2–3.4 cm. [James & Thrupp] are by no means uncommon. The type-specimen of *C. Tinneanum* shows a range of pedicel length varying from 1.5 to 4.2 cm. It would consequently fall under sections D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>, and D<sub>4</sub> of the key, were it not for the fact that it should be placed in section [AA].

As in the case of *A. coranica*, the vegetative and general floral characters of *A. Tinneana* are very plastic and are influenced to some extent by the age and vigour of the bulb.

Similarly the number of ovules in each loculus is extremely variable, and there appears to be no correlation between this and the other variable characters just dealt with, nor is the number of ovules in each loculus of any one plant correlated with its geographical location.

*A. Tinneana* appears to be most closely related to *A. coranica*. Both species have wide distributions which are complementary; from the data available these distributions do not overlap, but there is no evident gap between them. In the vegetative condition it would be almost impossible to separate these species. In flower, however, *A. Tinneana* may readily be distinguished from *A. coranica*, although the only important character is the length of the perianth-tube. In colour of perianth, in shape and pose of the perianth-segments, and in colour and length of stamens and style these species are strikingly similar.

The flowering period ranges from April and May in Ubangi-Shari to October, November and December in Bechuanaland, and is directly associated with the incidence of the rainy season.

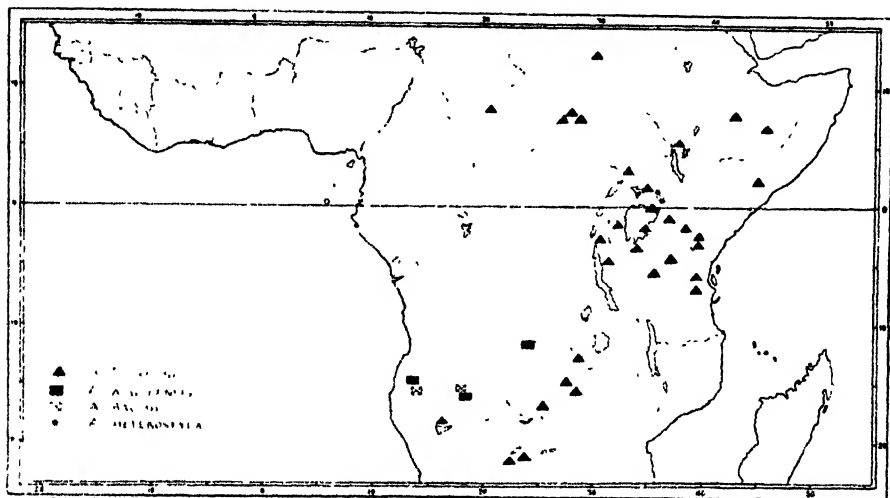
As a result of extended collecting during the last thirty years the apparent geographical isolation of most of these 'species' has disappeared. As may be seen from the accompanying map, the distribution is practically continuous from north to south, with the exception of an area covering part of south-western Tanganyika and north-eastern Rhodesia. This apparent gap is

probably accounted for by the scarcity of comprehensive collections from those areas made during any but the dry season.

We therefore find it impossible to recognize more than one of these species, and the epithet *Tinneana* is retained for it.

*Stenolirion Elliotii* Baker, based on a plant collected by Scott Elliot in Urundi, was described and figured in Hooker's 'Icones Plantarum', loc. cit. The genus has been generally accepted; it has remained monotypic, and no further material has since been identified with the species.

The type-specimen consists of the necks of two bulbs with the leaves attached, and two fruiting scapes one of which is still attached to the bulb. Consequently the only perianths present are very much shrivelled, and it is impossible to ascertain the actual shape and position of the various parts of the flower.



Distribution of *Ammocharis* spp. excluding *A. coranica* (Ker-Gawl.) Herb.

As illustrated, however, the length of the perianth-tube is definitely inaccurate; it is figured as being 4.5 cm. long, whereas examination of the type-specimen has shown it to be actually 7.0-7.5 cm. long.

Baker describes the fruit as being 'baccate'. This is incorrect, as the fruit is a more or less membranous capsule, apparently indehiscent and rupturing in an irregular way.

The seeds are described as being angled by pressure. Their shape as figured is due to shrinkage on drying. If soaked these seeds become fleshy, and a transverse section reveals the presence of a fleshy endosperm as found in the genera *Crinum*, *Ammocharis*, and *Nerine*. Baker's statement that the albumen is cartilaginous is incorrect and very misleading. Two seeds while still enclosed in the capsule had actually begun to germinate. This character is often met

with in genera such as *Crinum*, *Ammocharis*, *Cybistetes*, *Nerine*, etc., which are known to possess seeds with a fleshy endosperm, and in which the endosperm actually contains water as a reserve-food product (see Guppy, 'Studies on Seeds & Fruits', p. 504: 1912; and Molisch 'Pflanzenbiol. in Japan', p. 232: 1926).

Furthermore, the 'cut-off' leaves and their arrangement in a biflabellate manner are diagnostic characters of *Ammocharis*, and we have no doubt that *Stenolirion Elliotii* is conspecific with *A. Tinneana*. As a point of interest it may be mentioned that a sheet of *A. Tinneana* [Chevalier 8202 in Herb. Paris] was at one time thought to be a species of *Stenolirion*, but was subsequently identified as *Crinum ammocharoides* Baker.

3. *AMMOCHARIS HETEROSTYLA* (Bullock) Milne-Redhead et Schweickerdt, comb. nov.

*Crinum heterostylum* Bullock in Bull. Misc. Inform. Kew, 1932, p. 505 (1932); H. M. Gardner in Gard. E. Afr. p. 168 (1934). '*Crinum parvum* Baker' sec. Jex Blake in Yearb. Am. Amaryll. Soc. II, pp. 31, 32 (1935), non Baker.

*Bulb* ovoid, up to 9 cm. in diameter, and 11.5 cm. long including the neck, often with more than one crown of leaves. *Leaves* about 5-8, biflabellately spreading, strap-shaped, often falcate, variable in length and width, up to 35 cm. long, 1.2-2.8 cm. wide, striate, glaucous; margins scarious and minutely erose. *Scape* 8-13 cm. long, strongly compressed, smooth, spreading below, at length ascending. *Umbel* 3-10; spathe-valves 3-4.5 cm. long, 0.8-1.5 cm. wide, lanceolate, acute, papery, conspicuously veined; bracts filiform, obtuse, widened towards the apex. *Pedicels* 0.2-2.2 cm. long. *Perianth* white with a pink tube and a pink median line on the outside of the segments, shiny, sweetly scented; tube narrowly cylindrical, bluntly angled, slightly widened towards the throat, variable in length, 3.5-7.7 cm. long; lobe narrowly oblanceolate, obtuse, the three outer keeled with a cucullate apex, 2.2-4.0 cm. long, the inner rather shorter than the outer, 0.7-0.9 cm. wide, gradually spreading from the base and spreading or strongly recurved towards the apex. *Stamens* more or less erect, slightly exserted; filaments white, the outer about 5 mm. long, the inner about 10 mm. long; anthers about 4 mm. long, more or less straight. *Ovary* 6-10 mm. long, barrel-shaped, slightly wider than the pedicel and perianth-tube; ovules about 8-10 per loculus; style 4.5-5.8 cm. long, at first fairly short but increasing in length as the flower ages, apparently always included within the tube. *Fruit* not seen.

UGANDA. In peaty soil on rocks at Kabaroni, N. slopes of Mt. Elgon, 1800-2100 m., 12 April 1927, Snowden 1055 (K, type, BM):—plant 6-12 inches high; bulb large; flowers white with pale pink stripes and red outside; Sabir name *Singotyo*.

KENYA COLONY. Mt. Elgon, 2300 m., Dec. 1930, Lugard 421 (K):—plant 6 inches high; leaves flat, ribbon-like; stem flat; flowers cream veined pink

or yellow. In shallow soil on exposed rocky patches on the S. side of Mt. Elgon, 1800–2100 m., Feb. 1930, *Gardner*, Forestry Herb. 2276 (K):—small plants; flowers white inside and pink outside. Near Kitale, 1890 m., Feb. 1935, *Mrs. Tweedie* 282 (K):—the long dead leaves attached to the living ones and more especially the square ends of the leaves are characteristic; leaf with perfect tip never seen; leaves are put forth with every shower in the dry season, more drought follows, and the leaves wither down to the tip of the bulb at the surface of the soil. Trans-Nzoia District, amongst rocks on Mt. Elgon, 2,000 m., 5 March 1935, *G. Taylor* 3840 (BM):—flowers white to pink on same head.

**CULTIVATED.** Grown in Kenya by Lady Muriel Jex Blake from bulbs from Mt. Elgon, Jan. 1935, *Napier* 3617 (K):—sweet-scented flowers, creamy white or pink. Grown in Royal Botanic Gardens, Kew, 5 Feb. 1937, collected by Mt. Elgon Nurseries s.n. (K).

It is unfortunate that a species so recently described is already in cultivation under an incorrect name. Specimens were introduced from Kenya Colony into the United States of America by Lady Muriel Jex Blake under the name *Crinum parvum*. It is difficult to understand how this misidentification took place, for *C. parvum* Baker is a very different plant indigenous in the Zambezi Valley.

The following account, together with an excellent figure and beautiful material of this very local species, has been received from Mrs. D. R. Tweedie, of Kitale, Kenya Colony, to whom we are greatly indebted:—

The locality, so far as I can say, is the slopes of Elgon on the Kenya side from 6,300' to about 8,500'. I do not know if it is found on the Uganda side, nor if it is found in other parts of Kenya. The Trans-Nzoia district, of which Kitale is the centre, consists of a plain bounded on the east by the Cherangani Hills, and on the west by Mt. Elgon. I think I can state positively that this *Ammocharis* is not found either on the plain or in the Cherangani Hills, but only on Mt. Elgon.

The habitat is bush country, i.e., small trees dotted about sparsely in the grass, which usually gets burnt off in the dry weather, but grows very thick and to 3' or even 4' high in the rains. It is very fertile country, and the Elgon soil differs from that of the rest of the district, being volcanic, black and quite lacking in sand. *Ammocharis heterostyla* is usually found near patches of outcrop rock, but I cannot say whether this is always so. Where found it is very numerous, but it is not found everywhere, e.g. there is none on this farm of 1,000 acres, yet on the next farm, of about the same size and exactly the same type of country, there is one ridge where it is dotted about over an area of 100 acres, and there is also some on another ridge.'

*A. heterostyla* is related to *A. angolensis* from Angola and Northern Rhodesia. Both species have flowers somewhat pale in colour, perianth-segments not spirally recurved, and stamens only slightly exerted from the perianth-tube.

The epithet '*heterostylum*' originally chosen for this plant is somewhat



misleading, as true heterostyly does not occur, the length of the style probably being correlated with the age of the flower ; the style appears always to remain included within the perianth-tube.

4. *AMMOCHARIS ANGOLENSIS* (Baker) *Milne-Redhead et Schweickerd*t, comb. nov.

*Buphane angolensis* Baker in Journ. Bot. XVI, p. 197 (1878) ; Benth. & Hook. f. Gen. Pl. III, p. 730 (1885). *Crinum angolense* (Baker) Benth. ex Baker, Handb. Amaryll. p. 80 (1883) ; Engl. in Abh. Preuss. Akad. Wiss. 1891, p. 170 (1892) ; Baker in Dyer, Fl. Trop. Afr. VII, p. 397 (1898) ; De Wild. Plant. contre la Lèpre, p. 17 (1937). *Crinum curvifolium* Baker in Warb. Kunene-Samb. Exped. p. 565 (1903) ; De Wild. Plant. contre la Lèpre, p. 18 (1937).

*Bulb* ovoid-spherical, about 8 cm. diameter. *Leaves* about 8, biflabbellately spreading, strap-shaped, often falcate, variable in length, up to 25 cm. long and 2.8 cm. wide, striate, glabrous, sometimes rather glaucous ; margins scarious and minutely erose. *Scape* about 11 cm. long (including 6.5 cm. below ground), glabrous, smooth. *Umbel* 6-12-flowered ; spathe valves 3.8-6 cm. long, 1-1.5 cm. wide, lanceolate, subacute, papery, conspicuously veined ; bracts filiform, widened towards the obtuse apex. *Pedicels* 3-10 mm. long. *Perianth* pinkish-red or pinkish-white outside, paler or white inside ; tube narrowly cylindrical, slightly widened towards the apex, 5.0-8.7 cm. long ; lobes narrowly oblanceolate, obtuse, 3.0-4.5 cm. long, 3-5 mm. wide, spreading from the base, curved but not spirally recurved towards the apex. *Stamens* more or less erect, exerted from the tube ; filaments 1.0-3.2 cm. long ; anthers 2.5-6 mm. long, curved or the shorter ones more or less straight. *Ovary* 1.0-1.4 cm. long, cylindrical or barrel-shaped, slightly wider (in the dry state) than the pedicel and the perianth-tube ; ovules 7-17 per loculus ; style 4 cm. long, either included within or exerted from the perianth-tube. *Fruit* not seen.

ANGOLA. Huilla. In thicket-grown rather damp pastures near Mumpula and Lopolo, about 1650 m., April 1860, *Welwitsch* 4012 (BM, type, K) :—bulb large, ovate-spherical ; leaves appearing after the flowers, bifariously sheathing, curved to prostrate, obtuse, serrulate, glabrous ; flowers dull rose-coloured, fragrant. Bie. In sandy soil by R. Matunguë, tributary of the Cúebe, 1150 m., 26 Oct. 1899, *Baum* 331 (Be, type of *C. curvifolium*, BM, K, Z) :—plants up to 30 cm. high ; leaves arranged in two groups ; flowers red. Moxico. Frequent on seasonally wet shallow soils overlying 'laterite' in open grassland between R. Mujilezhi and the Lusavo Falls, in leaf only, Jan. 1938, *Milne-Redhead* s.n. (photograph, K).

NORTHERN RHODESIA. Mwinilunga District. SW. of Matonchi Farm towards R. Ysongailu, locally plentiful on seasonally wet shallow soils overlying 'laterite' in open grassland, 1400 m., 22 Feb. 1938, *Milne-Redhead* 4659 (K) :—leaves arranged in two opposite fans, ascending, not adpressed to the ground, green ;

no flowers or fruits present. Same locality, 29 Sept. 1938, *Paterson* M7(K):—bulb round, about 3 inches in diameter; tepals pinkish-white outside, white inside; ends of tepals lemon-yellow; anthers yellow.

Both *A. angolensis* and *A. curvifolia* were founded on single gatherings, and up till recently had never been re-collected. Whilst it was quite clear that these two species were very closely related, it was found that they differed in certain characters (the lengths of perianth-tube and -lobes, filaments, anthers, and style), in consequence of which we, somewhat reluctantly in the absence of further evidence, decided to consider them distinct. Happily a fine gathering, collected by Capt. K. R. Paterson at Matonchi Farm, Mwinilunga, Northern Rhodesia, arrived at Kew just before the MS. was ready for press. This gathering showed most conclusively that these characters are unreliable for diagnostic purposes and that *A. curvifolia* is undoubtedly conspecific with *A. angolensis*. A table giving these characters from the six specimens (A–F) collected by Capt. Paterson and also from the Kew sheets of the type-gatherings of *A. angolensis* and *A. curvifolia* is shown, and it will be seen that not only is there a large variation in every character but that there is no correlation between the different characters.

In Northern Rhodesia and in the adjacent parts of Angola, where *A. angolensis* has recently been observed by one of us, the species is characteristic of the 'lateritic' grasslands in places where *Loudetia simplex* (Nees) C. E. Hubbard ceases on account of the proximity to the surface of the relatively impervious concretionary ironstone layer (known locally as 'laterite') and the consequent seasonal flooding of the ground, and it was almost exclusively associated with a broad-leaved species of *Eriospermum*. *A. angolensis* was in leaf from November onwards, and no trace of the plants having produced flowers and fruits was observed. Through the co-operation of Capt. Paterson, well-preserved inflorescences from these plants have now been obtained.

5. AMMOCHARIS BAUMII (*Harms*) *Milne-Redhead et Schweickhardt*, comb. nov.

*Crinum Baumii* Harms in Warb. Kunene-Samb. Exped. p. 199 (1903); De Wild. Plant. contre la Lèpre, p. 18 (1937).

*Bulb* ovoid, up to 2.5 cm. in diameter and 6 cm. long including the 2–3 cm. long neck; outer tunics firmly chartaceous, dry, brown, inconspicuously striate, glabrous and smooth. *Leaves* 2–6, more or less erect, linear, 3.5–5.5 cm. long, about 1 mm. [4 mm. in Newton] wide, striate, glabrous; margins entire. *Scape* 1–4 cm. long, 1.5–2 mm. in diameter, glabrous, smooth, erect. *Umbel* 1-flowered; spathe-valves up to 3.5 cm. long, 2–4 mm. wide, narrowly lanceolate, acute, hyaline, conspicuously veined; bract 0. *Pedicels* 0–2 mm. long. *Perianth* white or pink; tube narrowly cylindrical, 9.5–12 cm. long; lobes linear-lanceolate, obtuse, 5–7 cm. long, 3 mm. wide, recurved from the base. *Stamens* more or less erect, slightly spreading, much exserted from the

TABLE.—Certain characters taken from the type-gatherings of *A. angolensis* and *A. curvifolia* compared with the same characters taken from six specimens (A-F) from a single locality in Northern Rhodesia.

	No. of flowers per umbel.	Length of perianth-tube.	Length of perianth-lobes.	Length of filaments.	Length of anthers.	Style.
<i>A. angolensis</i> .	10	5-6 cm.	3.5-4 cm.	1.0-1.4 cm.	3.0-3.5 mm.	included.
<i>A. curvifolia</i> .	?	8-8.5 cm.	3.0-3.5 cm.	2.0-2.3 cm.	4.0-5.0 mm.	exserted.
Specimen A	9	6.5-7 cm. (i)	3.0-3.2 cm. (c)	1.7-2.5 cm. (c)	2.5-3.0 mm. (+a)	included (a).
B	11	7.0-7.5 cm. (i)	3.0-3.2 cm. (c)	2.0-2.7 cm. (c)	4.0-4.5 mm. (c)	included (a).
C	12	6.5-7 cm. (i)	3.0-3.2 cm. (c)	2.4-3.2 cm. (-c)	3.0-3.5 mm. (a)	exserted (c).
D	11	8-8.5 cm. (c)	4.5 cm. (+a)	2.8-3.0 cm. (+c)	4.5-5 mm. (c)	exserted (c).
E	12	5.5 cm. (a)	3.5-4 cm. (a)	2.0-2.5 cm. (c)	4.5-5 mm. c)	exserted (c).
F	12	7.5-8.7 cm. (c)	3.5-4 cm. (a)	2.0-2.5 cm. (c)	4.5-6 mm. (c)	exserted (c).

(a) = *angolensis* character.

(c) = *curvifolia* character.

(i) = intermediate character.

(+) = extreme character.

tube ; filaments up to 6 cm. long ; anthers about 9 mm. long, strongly curved. *Ovary* 4–6 mm. long, cylindrical or barrel-shaped, slightly wider than the pedicel and perianth-tube ; ovules 4–5 per loculus ; style filiform, exerted about 5 cm. beyond the perianth-tube. *Fruit* not seen.

ANGOLA. River Kubango above Chirumbu, rare on damp soil, 1,200 m., 14 Oct. 1899, *Baum* 273 (Be, type, BM, K, V, Z) :—bulbous plant, 10–20 cm. high ; flowers white or pink. Gambos mission station, Huilla, Nov. 1882, *Newton* s.n. (Be).

*A. Baumii* may be considered an extremely advanced species with no known close relative. Its affinities are with *A. Tinneana*, but in many respects it is very different. The leaves are much narrower than those of any other *Ammocharis*, and it is not known if their arrangement is distichous and biflabellate or is not ; in other respects they are characteristic of *Ammocharis*. It is conceivable that they may be found *not* to be biflabellately arranged, for owing to their narrowness the necessity for this arrangement has disappeared.

Up to the present time only single-flowered umbels are known, which is a reason for considering this species an advanced one. The individual flower resembles that of *A. Tinneana*, but is more slender and delicate. However, it has the long perianth-tube, the spirally recurved perianth-segments and the well exerted filaments and style of that species.

#### DOUBTFUL SPECIES

*Crinum nerinoides* Baker in Bull. Herb. Boiss. ser. 2, II, p. 666 (1903) ; De Wild. Plant. contre la Lèpre, p. 20 (1937). This is most probably an *Ammocharis*, but the type material (*Dorr* s.n. in Herb. Zürich) is too incomplete to be placed with certainty.

*Crinum ondongense* Baker in Bull. Herb. Boiss. Ser. 2, II, p. 666 (1903) ; De Wild. Plant. contre la Lèpre, p. 20 (1937). The species is based on very poor material (*Rautanen* s.n. in Herb. Zürich) consisting of a bulb, a detached part of a leaf, and a detached part of an inflorescence. The leaf is probably that of a species of *Crinum*, but does not belong to the inflorescence, which is that of an *Ammocharis* too imperfect to determine specifically.

#### EXCLUDED SPECIES

*Ammocharis falcata* (Jacq.) Herb. App. p. 17 (1821) = *Cyristetes longifolia* (Linn.) *Milne-Redhead & Schweickerdt*.

*Ammocharis longifolia* (Linn.) Roem. Amaryll. p. 62 (1847) = *Cyristetes longifolia* (Linn.) *Milne-Redhead & Schweickerdt*.

*Ammocharis Slateriana* (Herb. ex Lindl.) Kunth, Enum. Pl. v, p. 613 (1850) = *Brunsvigia Slateriana* (Herb. ex Lindl.) Baker, Handb. Amaryll. p. 97 (1888).

*Ammocharis Taveliana* Schinz in Verh. Bot. Ver. Prov. Brand. xxxi, p. 214 (1890), quoad folia [*Crinum Tavelianum* (Schinz) Fritsch]=*Boöphone disticha* (Linn. f.) Herb. in Bot. Mag. LII, sub t. 2578 (1825).

*Ammocharis Herrei* Leighton in S. Afr. Gard. & Country Life, xxii, p. 110 (1932). The flowers in the type-specimen appear similar to those of *Cyristetes longifolia*, but the number of flowers per umbel is greater, the pedicels are longer, and the number of ovules (2-4) per loculus is smaller than is usual in that species. Until the fruit is known it is not possible to refer it to the correct genus.

Peers specimen in Bolus Herbarium 16389 (BH) shows some resemblance to *A. Herrei*, and for similar reasons we have been unable to assign it to a genus.

A photograph in the Kew Herbarium received from Mr. H. Herre shows a plant growing at the Stellenbosch University Gardens, April 1934, under the name *Ammocharis Herrei*. This plant, however, undoubtedly is *Ammocharis coranica*.

#### THE GENUS CYBISTETES *Milne-Redhead et Schweickerd.*

The biflabellate arrangement of the leaves of *Cyristetes* is so like that of *Ammocharis* Herb. emend. that, in the absence of flowers or fruits, it is not possible to distinguish the two genera. This arrangement is not known to occur in any other genus of Amaryllidaceae. The leaf-blades in *Cyristetes*, as in *Ammocharis*, periodically die back to the bulb, and the leaf-bases later on grow out to form new blades.

The flower of *Cyristetes* differs from that of *Ammocharis* in having declinate stamens, while the perianth-segments of the only known species are more imbricate below, the flower being not unlike that of *Amaryllis Belladonna* though on a smaller scale.

In fruit, however, the genus is very different from all the closely allied genera. After flowering the pedicels elongate, stiffen, and the outer (lowermost) spread downwards, the infructescence so formed recalling that of *Brunsvigia* Heist. and *Boöphone* Herb. Whereas *Brunsvigia* and *Boöphone guttata* (Linn.) Herb.\* have a loculicidally dehiscent capsule, that of *Cyristetes* agrees with *Boöphone disticha* (Linn. f.) Herb. in being indehiscent†. Apart from the nature of the infructescence and the similarity of the seeds, there appears to be no close relationship between these genera, as the character of the placentation, the shape of the flower, and the leaf-arrangement are strikingly different.

\* The usually adopted name, *B. ciliaris* (Linn.) Herb., is illegitimate, since *Amaryllis ciliaris* Linn. (Sp. Pl. ed. 2, p. 422 : 1762), on which the combination is based, was merely a new name for *A. guttata* Linn. (Sp. Pl. ed. 1, p. 294 : 1753).

† The presence of different types of capsules in *Boöphone* Herb. suggests the need for investigation into the limits of this genus.

The placentation, as was stated by Herbert (App. p. 48), is exactly similar to that of *Ammocharis coranica*, the ovules being attached by one whole side to the placenta, as is the case in both *Ammocharis* and *Crinum*. In both *Cydistetes* and *Ammocharis* the number of ovules in each loculus is variable.

The seeds are fleshy, more or less globose, often angled by pressure, like those of *Ammocharis*, *Crinum*, and *Boöphone*, and they show a similar tendency to germinate while still enclosed in the capsule.

It is probable, therefore, that *Cydistetes* is more closely related to *Ammocharis* than to any other genus.

*CYDISTETES* Milne-Redhead et Schweickhardt, gen. nov.

*Amaryllis* Linn. Sp. Pl. p. 292 (1753), quoad speciem 7; Gen. Pl. ed. 5, p. 142 (1754), pro parte; ed. 6, p. 162 (1764); ed. 7 (Reich.), p. 165 (1778); ed. 8 (Schreb.), p. 217 (1789); ed. 9 (Haenke), p. 303 (1791); Syst. Nat. ed. 10, p. 977 (1759); ed. 13, 2, p. 236 (1770); ed. 13 (Gmel.), p. 538 (1791); Mill. Gard. Dict. ed. 8. no. 7 (1768); Linn. Syst. Veg. ed. 13, p. 264 (1774); ed. 14, p. 319 (1784); ed. 15 (Murr.), p. 339 (1797); Reichard, Syst. Pl. II, p. 25 (1779); Houtt. Handl. Pl. Kruidk. XII, p. 166 (1780); Murr. Syst. of Veg. p. 253 (1782); Lam. Encycl. I, p. 120 (1784); L'Hérit. Sert. Angl. p. 9 (1788); Linn. f. in Ait. Hort. Kew. I, p. 415 (1789); Willd. Sp. Pl. II, p. 50 (1799); Pers. Syn. I, p. 352 (1805); Linn. f. in Ait. Hort. Kew. ed. 2, II, p. 223 (1811), omnes pro parte. '*Haemanthus* Linn.' sec. Thunb. Prod. Pl. Cap. p. 58 (1798), pro parte, non Linn.; Thunb. Fl. Cap. ed. Schultes, p. 296 (1823), pro parte. '*Brunsvigia* Heist.' sec. Ker-Gawl. in Bot. Mag. XXXV, t. 1443 (1812), pro parte, non Heist.; Herb. in Bot. Mag. XLVII, sub t. 2113 (1819), and in Trans. Hort. Soc. IV, p. 181 (1821); Spreng. in Linn. Gen. Pl. ed. 9, p. 275 (1830); Harv. Gen. S. Afr. Pl. p. 339 (1838), omnes pro parte. *Ammocharis* Herb. App. p. 17 (1821), pro parte; and Bot. Mag. LII, sub t. 2578 (1825); and Amar. II, pp. 77, 241 (1837); Roem. Amaryll. p. 61 (1847); Kunth, Enum. II, v, p. 611 (1850); T. Moore in Lindl. & Moore, Treas. Bot. I, p. 51 (1866); Harv. Gen. S. Afr. Pl. ed. 2, p. 382 (1868); Benth. & Hook. f. Gen. Pl. III, p. 727 (1883); Baker, Amar. II, p. 96 (1888); Pax in Engl. & Prantl, Pflanzenfam. II, 5, p. 108 (1888); Baill. Hist. Pl. XIII, p. 48 (1894); Baker in Dyer, Fl. Cap. VI, pp. 172, 203 (1896), and in Dyer, Fl. Trop. Afr. VII, pp. 377, 404 (1898); Engl. Pflanzenw. Afr. IX, 2, pp. 344, 350 (1908); Thonner, Blütenpfl. Afr. p. 146 (1908); Bailey, Stand. Cyclop. Hort. I, p. 274 (1914); Marloth, Fl. S. Afr. IV, p. 115 (1915); Thonner, Flow. Pl. Afr. p. 138 (1915); Phillips, Gen. S. Afr. Flow. Pl. pp. 160, 163 (1926); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, p. 409 (1930); Baker in Yearb. Am. Amaryll. Soc. I, p. 32 (1934); Hutch. Fam. Flow. Pl. II, p. 134 (1934), & in Yearb. Am. Amaryll. Soc. II, p. 78 (1936), omnes pro parte. *Brunsvigia* Heist. sect. *Ammocharis* (Herb.) Schult. Syst. Veg. VII, p. 850 (1830), pro parte; Endl. Gen. Pl. p. 177 (1836), pro parte; Meissn. Gen. Pl. Fasc. p. 394 1842 teste Pfeiffer), pro parte. *Brunsvigia* Heist. subgen. *Ammocharis* (Herb.) Spach, Hist. Nat. Veg. XII, p. 423 (1846). *Palinetes* Salisb.

Gen. p. 116 (1866), pro parte, nomen illegit. '*Nerine* Herb.' sec. Baker in Journ. Bot. xvi, pp. 163, 167 (1878), pro parte, non Herb.

*Bulbus* sphaerico-ovoideus, tunicatus, saepe superne conspicue attenuatus. *Folia* falcato-ligulata, 1-3 juniora apice incolumbia rotundata, vetustiora apice semper manca et truncata, disticha, biflabellatim disposita, plerumque patentia vel solo adpressa, usque ad apicem bulbi sub finem cujusque temporis incrementi marcescentia, basibus eorundem foliorum proximo tempore ita recrescentibus ut folia nova efficiant, probabiliter per compluria tempora incrementi persistentibus; margines plerumque scariosi, conspicue erosi. *Scapus* lateralis, compressus, solidus. *Umbella* 13-24-flora, floribus manifeste seriatim (centripetaliter) expansis. *Spathae* valvae 2, persistentes, tenuiter coriaceae. *Bractae* filiformes, apicem versus plerumque ampliatae, persistentes. *Pedicelli* plus minus trigoni, longitudine varii, sub fructu valde elongati, rigidi et quoquoersus radiantes. *Flores* zygomorphi. *Perianthii* tubus saepe angulum cum pedicello efformans, subcylindricus, sursum leviter ampliatus, obtuse angulatus. *Perianthii* lobi subaequales, valde obtuse carinati, tubo multo longiores, inferne etiam sub anthesi imbricati, apicem versus sensim patentes, cum tubo perianthium infundibulare efformantes, lobi exteriores apice valde cucullati, interiores latiores et minus cucullati, pro aetate plus minus rubidi. *Stamina* ori perianthii tubi affixa; filamenta filiformia, ultra tubum valde exserta, *declinata*, inaequalia, interiora exterioribus sublongiora; antherae lineari-oblongae, curvatae, dorsifixae, paullulum infra medium connectivum affixae, versatiles. *Ovarium* obtuse angulatum: ovula 8-18 pro loculum, biseriatim disposita, per totum latum suum placentae affixa. *Stylus* filiformis, trigonus, bene exsertus, *declinatus*. *Stigma* integrum, minute 3-sulcatum, papillosum. *Capsula* indehiscens, clavata vel fusiformi-obovoidea, triquetra, valde 6-costata, membrana inter costas persistentes demum ita irregulariter rupta et marcescente ut semina sint liberata. *Semina* carnosae, pallide cinereo-viridia, subglobosa vel obtuse angulata, saepe in capsula germinantia; embryo recta; endospermium copiosum.

CYBISTETES LONGIFOLIA (Linn.) Milne-Redhead et Schweickerd, comb. nov.

*Amaryllis longifolia* Linn. Sp. Pl. p. 293 (1753); ed. 2, p. 421 (1762); ed. 3, p. 421 (1764); Syst. Nat. ed. 10, p. 977 (1759); ed. 12, 2, p. 237 (1767); ed. 13, 2, p. 237 (1770); ed. 13 (Gmel.), 2, p. 539 (1791); Mill. Dict. ed. 8, no. 7 (1768); abbr. ed. 6, no. 7 (1771); Weston, Bot. Univ. II, p. 31 (1771); Linn. Syst. Veg. ed. 13 (Murr.), p. 265 (1774); ed. 14 (Murr.), p. 320 (1784); ed. 15 (Murr.), p. 340 (1797); Reichard, Syst. Pl. II, p. 27 (1779); Houtt. Handl. Pl. Kruidk. XII, p. 177 (1780); Murr. Syst. of Veg. p. 253 (1782); Lam. Encycl. I, p. 122 (1784); Mill. Dict. Jard. p. 144 (1785); Vitm. Summa Pl. II, p. 284 (1789); Pers. Syn. I, p. 354 (1805), pro parte, excl. descr. et cit. Ait. & Jacq.; Turt. Syst. of Nat. v, p. 531 (1806); Mill. Gard. Dict. ed. Martyn, no. 13 (1807), pro parte, excl. descr. et cit. Ait. & L'Hérit. *Crinum falcatum* Jacq. Hort. Vind. III, p. 34, t. 60 (1776); Linn. Syst. Veg. ed. 14 (Murr.), p. 319 (1784); Vitm. Summa Pl. II, p. 282 (1789); Mill. Dict. Jard. Suppl. I, p. 349 (1790).

*Amaryllis falcata* (Jacq.) L'Hérit. Sert. Angl. p. 13 (1788); Linn. f. in Ait. Hort. Kew. I, p. 418 (1789); ed. 2, II, p. 225 (1811); Willd. Sp. Pl. II, p. 55 (1799); Dietr. Lex. Gartn. u. Bot. I, p. 327 (1802); Pers. Syn. I, p. 354 (1805); Turt. Syst. of Nat. v, p. 531 (1806); Mill. Gard. Dict. ed. Martyn. no. 11 (1807); Poir. in Lam. Encycl. Suppl. I, p. 318 (1810); Herb. in Bot. Mag. XLVII, sub. t. 2113 (1820); Spreng. Syst. Veg. II, p. 52 (1825); Dietr. Syn. Pl. II, p. 1181 (1840). *Crinum longifolium* (Linn.) Thunb. Prodr. Pl. Cap. p. 59 (1794), pro parte, quoad nomen tantum, excl. descr. et loc. *Haemanthus falcatus* (Jacq.) Thunb. Prodr. Pl. Cap. p. 58 (1794); Fl. Cap. II, p. 255 (1818), pro parte; ed. Schultes, p. 297 (1823), pro parte. *Brunsvigia falcata* (Jacq.) Ker-Gawl. in Bot. Mag. XXXV, t. 1443 (1812); Herb. in Bot. Mag. XLVII, sub. t. 2113 (1819), & in Trans. Hort. Soc. IV, p. 181 (1821); Lodd. Bot. Cab. VIII, t. 745 (1823); Schultes, Syst. Veg. VII, p. 851 (1830); Geel, Sert. Bot. Cl. p. 6 (1832); Reichb. Fl. Exot. III, p. 34, t. 191 (1835); Spach, Hist. Nat. Veg. XII, p. 423 (1846); Nichols. Dict. Gard. I, p. 216 (1884). *Ammocharis falcata* (Jacq.) Herb. App. p. 17 (1821); Roem. Amaryll. p. 62 (1847); Kunth, Enum. Pl. v, p. 612 (1850); Benth. & Hook. f. Gen. Pl. III, p. 727 (1883); Pax in Engl. & Prantl, Pflanzenfam. II, 5, p. 108 (1888); Baker, Handb. Amaryll. p. 96 (1888), pro parte, excl. syn.; Dur. & Schinz, Consp. Fl. Afr. v, p. 253 (1893), pro parte, excl. syn.; Baker in Dyer, Fl. Cap. VI, p. 204 (1896), pro parte, excl. syn.; Rendle in Journ. Bot. XXXIX, p. 372, fig. i (1901); Bolus & Wolley-Dod in Trans. S. Afr. Phil. Soc. XIV, p. 338 (1903); Harmer, Wild Flow. Cap. p. 73 (1926); Herre in Gartenfl. LXXV, p. 315 (1926); Levyns, Guide Flow. Cap. Pen. p. 73 (1929), pro parte, excl. descr. gen.; Duthie in Ann. Univ. Stellenb. VII, Reeks A, Af. 4, pp. 15, 21, 34 (1929), and VIII, Reeks A, Af. 4, p. 18 (1930); Pax & K. Hoffm. in Engl. Pflanzenfam. ed. 2, xv a, 409 (1930), pro parte, excl. syn.; L. Bolus in S. Afr. Gard. & Country Life, XXI, p. 244 (1931); Markötter in Ann. Univ. Stellenb. XIV, Reeks A, Af. 2, p. 13 (1936). *Ammocharis longifolia* (Linn.) Roem. Amaryll. p. 62 (1849); Kunth, Enum. Pl. v, p. 612 (1850), ambao pro parte, excl. descr. et syn. Thunb. *Amaryllis coranica* var. *pallida* Lindl. [sphalm. Burchell] sec. Markötter in Ann. Univ. Stellenb. XIV, Reeks A, Af. 2, p. 13 (1936), non Lindl.

#### Pre-Linnaean references

*Narcissus pumilus indicus polyanthos* Cornut. Canad. p. 153, t. 57 (1635); Rudb. Elys. p. 89, fig. 9 (1701). *Lilio-Narcissus indicus pumilus polyanthos* Moris. Hist. Pl. II, p. 368 (1680). *Lilium africanum humili longissimus foliis polyanthos saturate colore purpurasceus* Herm. Hort. Acad. Lugd.-Bat. Cat. p. 682 (1687); Herm. Parad. Bat. p. 195, t. 195 (1698). *Lilio-Narcissus africanus platycaulis humilis flore purpurascente odorato* Comm. Hort. Amst. I, p. 71, t. 36 (1697); Rudb. Elys. p. 180, fig. 8 (1701). *Lilio-Narcissus africanus pumilus polyanthos* Tourn. Inst. p. 386 (1700); Boerh. Ind. Alt. Pl. II, p. 147 (1720). *Amaryllis spatha multiflora corollis campanulatis aequalibus scapo compresso longitudine umbellae* Royen Fl. Leyd. Prodr. p. 36 (1740); Mill.



Gard. Dict. ed. 6, no. 7 (1752); abbr. ed. 4, no. 7 (1754); ed. 7, no. 7 (1759); abbr. ed. 5, no. 7 (1763); ed. 7 (Dublin), no. 7 (1764).

*Bulb* ovoid, about 10–11 cm. in diameter, up to about 18 cm. long including the neck, tunicated. *Leaves* 9–13, strap-shaped, often falcate, variable in length and width, 1.3–1.6 cm. wide, 6–40 cm. long, striate, smooth, glabrous, glaucous, margins scarious and conspicuously erose or almost entire. *Scape* 12–20 cm. long, ancipitous, glabrous, smooth, erect. *Umbel* 13–24-flowered. *Spathe-valves* 4–7.5 cm. long, 2–4 cm. wide, broadly lanceolate, more or less acute, thinly coriaceous, rather opaque, conspicuously nerved; bracts filiform, obtuse, usually widened at the apex. *Pedicels* angular, at the time of flowering 5–11 cm. long, elongating and rigid in fruit. *Perianth* varying in colour from pale to dark pink, shiny, sweetly scented; tube subcylindrical, widening slightly towards the mouth, variable in length, 0.8–1.5 cm. long; lobes oblanceolate, obtuse, 4–6.5 cm. long, 0.8–1.4 cm. wide, imbricate below, gradually spreading towards the apex. *Stamens* unequal, slightly spreading, *declinate*, exserted from the tube; filaments filiform, 3–4.7 cm. long; anthers 4–8 mm. long, curved. *Ovary* about 10 mm. long, hardly distinguishable from the apex of the pedicel and the base of the tube; ovules 8–18 per loculus; style filiform, triangular in section, exserted 4–6.2 cm. beyond the perianth-tube. *Fruit* with the pedicel elongate, clavate; capsule indehiscent, pyriform, ovoid, ellipsoid to subfusiform, about 3.5–5 cm. long and 2 cm. in diameter, somewhat triquetrous with an additional median rib on each face, contracted towards the apex into a blunt beak often crowned with the remains of the perianth, drawn out below into the stout triquetrous much elongated pedicel. *Seeds* subglobose or somewhat bluntly angled by pressure, about 12 mm. in diameter, fleshy.

CAPE PROVINCE. Paarl District. Roadside near Paarl, fl. March 1931, *Bolus* in Bolus Herb. 21380 (BH). In the plain along the Berg River, fl. 18 April 1847, *Prior* s.n. (K). Plains at base of Klein Drakenstein Mountains, near farm 'Salem', 18 March 1931, *Galpin* 11075 (NH):—only one specimen found, flowers pale pink. Stellenbosch District. Stellenbosch Flats, on the golf course, April 1932, *Duthie* in Bolus Herb. 21379 (BH, K):—flowering March, fruiting April. *Duthie & Herre* s.n. (K, NH):—flowering March 1937, leaves May 1937, fruiting June 1937. *Duthie* in Herb. Stellenbosch 764 (St):—flowers pink. *Duthie* in Herb. Stellenbosch 1204 (St):—flowers March 1923. *Duthie* in Herb. Stellenbosch 1022 a (St):—leaves May 1923. Railway embankment, Viedenberg Farm, Stellenbosch, 17 April 1920, *Garside* 1381 (K) (St. no. 1022):—flowers mallow-pink, pollen cream. Stellenbosch Flats, 4 Sept. 1920, *Garside* 1529 (K):—leaves only. *Duthie* in Nat. Bot. Gardens, 1353/26 (K):—flowered at Kirstenbosch 10 Feb. 1937, fruiting March 1937. Cape Peninsula. Cape Flats, sandy places near 'Riet-valley', fl. Feb., *Zeyher* 4115 (V). On recently burnt north-western slopes of Lion's Head Mountain, fl. April 1923, *Hamer* in Bolus Herb. 17384 (BH). Oudskip, *Middlemost* in Nat. Bot. Gdns. 117/25 (K):—flowered at Kirstenbosch Feb. 1937. Kommetje, south of Camps Bay,

fl. Jan. 1909, *Marloth* s.n. (NH). Without precise locality, 'e capite bona Spei', *Thunberg* (U). Swellendam District. Near Bonnie vale, fl. Jan. 1909, *Smith* in Bolus Herb. 21376 (BH). Without precise locality, April 1923, *Marloth* 11610 (NH) :—tepals pinkish-red, the throat white, scent strong.

The following account has been prepared from observations kindly made for us by Mrs. F. Isaac of the Bolus Herbarium and Dr. A. V. Duthie and Mr. H. Herre of the University of Stellenbosch, to whom we are very much indebted for their spirited co-operation and kind aid.

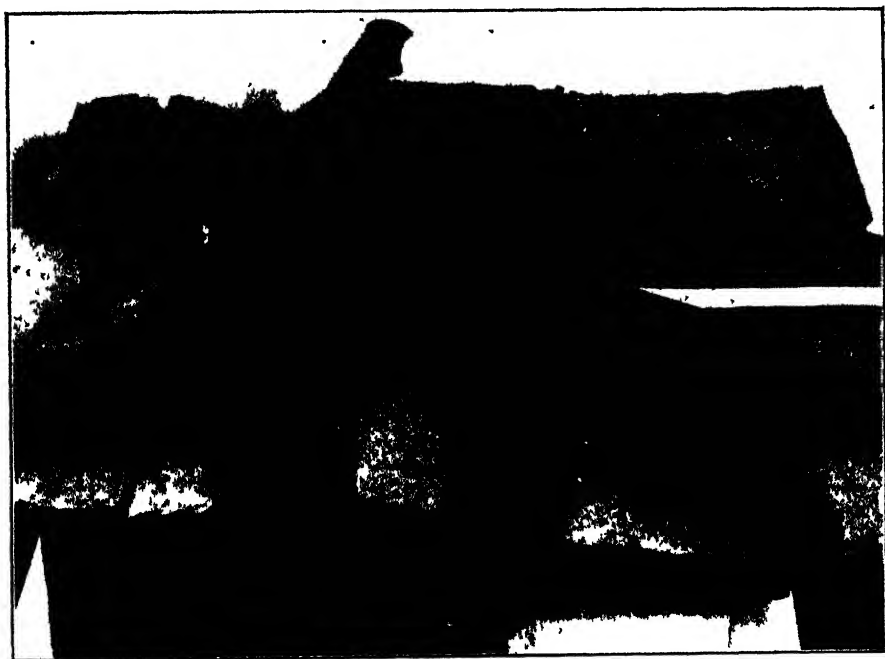


FIG. 2. —*Cyrtostylis longifolia* from Stellenbosch Flats, Capo Province, showing the bifurcate leaf arrangement. (Phot. H. Herre.)

The species flowered towards the middle of March 1937 at the end of the dry summer season, which was succeeded by the more rainy autumnal season, at the beginning of which no trace of foliage development was visible. The young inflorescences, protected by imbricate spathe-valves, emerged from between the bulb-scales and developed fairly rapidly. By the beginning of April some plants had already begun to set fruit, whereas others were still in full bloom.

In most cases the foliage leaves had appeared by the middle of May, but in some fruiting specimens no sign of leaf-development was then visible. The number of leaves in any one plant examined was found to vary from 9 to 13,

all except one or two of the younger having truncate apices. The width of the leaves was very variable and seemed to depend on the age and vigour of the plant. The ciliation of the leaf-margins also showed considerable variation even on the same plant. About 1-3 new leaves with entire apices are formed during any one growth-period, and a similar number of the outer older leaves die back to the neck of the bulb, cease to develop blades, and thus become bulb-scales. This remarkable behaviour is exactly similar to that met with in the genus *Ammocharis* Herb. emend.\*.

The flower-bud on opening is regular, except for one stamen which from the first is in a declinate position. In older flowers the stamens are definitely declinate and then tend to straighten out, the flower finally becoming more or less regular. The flowers open successively, and the colour varies a good deal in different specimens. The perianth-lobes in freshly opened flowers are white on the inner surface and white to pink on the outer surface, with conspicuous reddish-pink keels. As the flower becomes older the lobes turn a deep pink.

During anthesis the pedicels are 5-11 cm. long, but as the fruits mature the pedicels become rigid and elongate, reaching a final length of 8-15 cm. The young fruits are not unlike those of a *Brunsvigia*, but on maturing do not dehisce like a capsule. The mature fruits are subspherical to fusiform in shape according to the number of seeds developed. They often rupture before drying with the withered remains of the perianth still attached. As a rule a single vertical split appears first, but this is soon followed by others. The brittle papery tissue between the ribs tends to break down, leaving the ribs still attached to the pedicel. The heavy seeds are usually shed as the fruit dries, though some may fall soon after the living capsule-wall has begun to split.

Seed-dispersal, however, takes place mainly in the following way. The mature infructescences become detached from the bulb and are then blown or tumbled about by the wind. In the course of this 'tumbling' the seeds more readily break through the papery walls and fall to the ground. Mrs. F. Isaac of Cape Town and Mr. H. Herre of Stellenbosch have both kindly supplied evidence that the infructescence of *Cybistetes* is actually tumbled about by the wind. It has been observed also by Mr. John Martley of Banhoek, who 'found two ripe inflorescences blowing about the veld on the flats of Alderman's Farm, Firgrove, both containing ripe seed'.

The seeds of *Cybistetes*, like those of *Ammocharis* and *Crinum*, are large and fleshy and often germinate in the capsule. A drawing of a capsule which had ripened in October, and which had stood all winter, was made by Richard Salisbury on 26 April 1814, and showed the radicle of a germinating seed pushing through the papery tissue between the ribs (Rendle, loc. cit.). Capsules received at Kew from Stellenbosch University in 1937 contained seeds most of which were germinating.

\* This phenomenon has been studied by Markötter (loc. cit.) in cultivated specimens collected from the Stellenbosch Flats. Unfortunately she erroneously aligned the material with *Amaryllis coranica* var. *pallida* as figured in the Bot. Reg. tab. 1219, and, following Baker's synonymy, used the name *Ammocharis falcata* Herb.



AMMOCHARIS CORANICA (Ker - Gawl) Herb



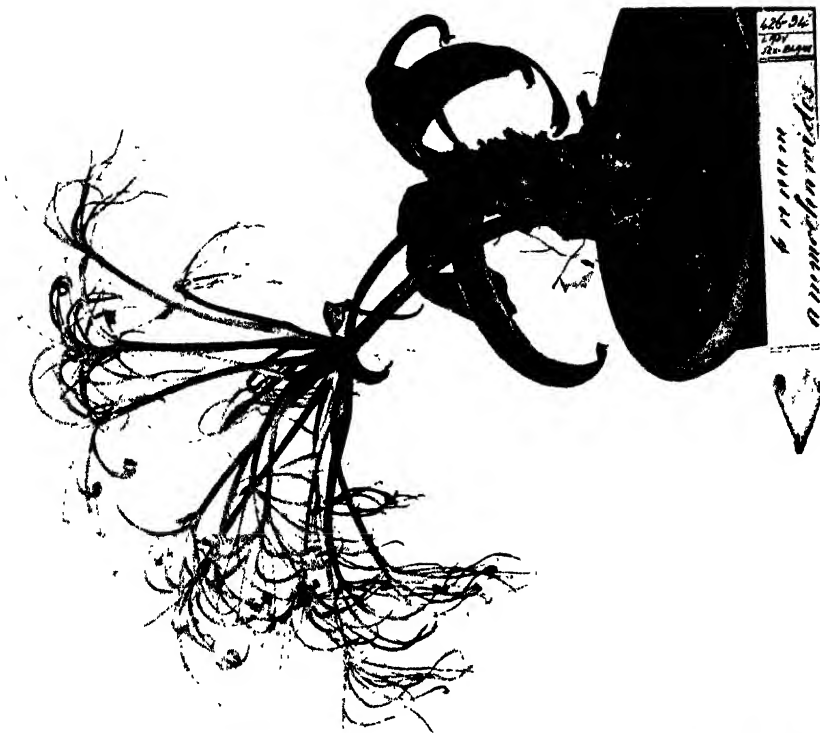
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**AMMOCHARIS HETEROSTYLA (Bullock)**  
Milne-Radhead and Schweickardt





AMMOCHARIS CORANICA (Ker-Gawl.) Herb.



Journal of Science & Commerce Ltd London

AMMOCHARIS TINNEANA (Kotschy and Peyr.)  
Milne-Redhead and Schweickardt.









Dr. Duthie further writes that a number of bulbs which had been uprooted and cut lengthwise by a spade (in order to destroy them ?) ' had developed a group of three or more small and very solid bulbils from the upper surface of the disk-like stem. The latter was dead and depleted of reserve food. The actual size of the bulbils was 8-20 mm. in diameter, with well-developed outer thick and reddish-green scales '. This mode of accidental vegetative propagation should be of some interest to anyone interested in growing this beautiful plant.

#### EXPLANATION OF THE PLATES.

- PLATE 2.**—On left : *Ammocharis coranica* (Ker-Gawl.) Herb. growing at Doornlaagte, Kimberley Distr., Cape Province. (Phot. J. Acocks.)  
On right : flowers of *Ammocharis heterostyla* (Bullock) Milne-Redhead & Schweickerdt, from a plant obtained on Mt. Elgon, Kenya Colony, and cultivated in the Royal Botanic Gardens, Kew. (Phot. G. Atkinson.)
- PLATE 3.**—*Ammocharis coranica* (Ker-Gawl.) Herb. from Damaraland, cultivated in Brussels Botanic Garden. (Phot. C. Bommer.)  
*Ammocharis Tinneana* (Kotschy & Peyr.) Milne-Redhead & Schweickerdt, from Kenya Colony, cultivated in the Royal Botanic Gardens, Kew. (Phot. G. Atkinson.)
- PLATE 4.**—*Cybisetes longifolia* (Linn.) Milne-Redhead & Schweickerdt ; on the left a mature infructescence from Stellenbosch Flats, Cape Province, and on the right some of the mature fruit and seeds, showing degree of variation in shape and size. (Phot. H. Herre.)



A review of the genus *Neuropogon* (Nees & Flot.) Nyl., with special reference to the Antarctic species. By I. MACKENZIE LAMB, B.Sc., F.L.S.

(With Plates 5-11 and 6 figures in the text)

[Read 10 November 1938]

THERE are perhaps few lichen genera in which critical taxonomic distinction has been so long delayed as in the genus *Usnea*. Its characteristically conspicuous habit has led to the accumulation of vast collections from nearly all parts of the world, and yet until quite recent times little or no attempt has been made to classify the enormous wealth of forms thus represented in a manner consistent with the critical taxonomic treatment accorded to other lichen genera. Determinations, in many cases admittedly provisional, of material from widely separated regions of the world gave the impression of a comparatively limited number of very widely ranging species.

The present paper is restricted to the consideration of a single section of the genus *Usnea*, or, as many workers prefer to regard it, a distinct genus, *Neuropogon* (Nees & Flot.) Nyl. As will be seen in the following sections, it comprises at present thirteen species, of which all but one occur only in the Southern Hemisphere.

The first attempt at a comparative account of the species of *Neuropogon*, if we neglect the enumeration of two species in Nylander's 'Synopsis Lichenum' (1860) and of three species in a paper by Stirton (1881) and Heber Howe's compilatory account (1915), was that of Du Rietz (1926). In this short but valuable contribution critical taxonomic treatment of the Southern Hemisphere species was introduced for the first time; fourteen species, some of which are now excluded from *Neuropogon*, were distinguished by means of a key based entirely on morphological characters.

Owing probably to the scarcity of available material in this group, no extension of these taxonomic studies was undertaken until J. Motyka embarked upon the tremendous task of compiling a world monograph of the genus *Usnea*. At the present time two volumes of this monumental work have appeared, and *Neuropogon*, there treated as a subgenus, is included in the first of these, published in 1936. Undoubtedly all lichenologists owe Motyka a debt of gratitude for his years of labour in attempting to introduce order into the previous chaos of ill-defined entities constituting this genus.

The present paper is not to be regarded as representing any attempt to set up a rival system of classification to that put forward in Motyka's work. Its only justification lies in the fact that the data which it embodies have been obtained from the comparative study of a large amount of recently collected Antarctic material now present in the British Museum Herbarium, and that the evaluation of these data has led to the first stages in the recognition of certain distributional phenomena which are of the greatest importance for systematic lichenology and geobotany as a whole. Also advantage has been taken of the recent studies by Asahina (1934 *a* & *b*, 1937) on the chemical constitution of lichens as applied to taxonomic research, and an attempt has been made to invoke the aid of these chemical criteria in the elucidation of the species here dealt with.

During a recent visit to Finland I was able to examine the specimens of *Neuropogon* collected by the Belgian Antarctic Expedition of 1897-9, and now in the Vainio Herbarium at Turku. The study of these brought to light many points of great systematic and distributional interest. Further type-material was obtained on loan from Vienna, Florence, and New York. Wherever possible, the actual type-specimens are shown in the Plates accompanying this paper.

Except in a few special cases, no detailed morphological descriptions of the species are given; for these reference may be made to Motyka's work. The remarks here appended merely provide certain supplementary data.

*Chemical characters and their place in lichen-taxonomy.*—When Nylander discovered that certain lichen species constantly give a characteristic colour reaction with potassium hydroxide or calcium hypochlorite (1867), he was concerned not so much with the investigation of the nature of the lichen substances producing these reactions, but with the practical elaboration of a quick and easy method whereby morphologically variable individuals of the same species might be recognized. Through the application of this method he was led to the recognition of a number of morphologically indistinguishable 'chemical species' separated only by their different colour reactions with the compounds mentioned above.

In later years the chemical constituents of a large number of species were analysed, and Zopf (1907) made the first attempt at framing a chemical classification of the lichen substances. This provisional classification has recently been extended and improved by Asahina (1934 *a*). Of particular interest for systematic lichenology is the latter author's work on a section of the Orcin-derivatives of Zopf to which he gives the name Depsidones. These Depsidones are derivatives of Phenolcarbonic acid in which two or more simple Phenolcarbonic acids unite as esters, with the linkage completed by an Oxygen atom in the *ortho*-position; they are not saponifiable with alkalis. In another paper (1934 *b*) Asahina has shown that those Depsidones which are  $\beta$ -Orcin derivatives are aldehydes forming characteristically coloured condensation-products

with the aromatic Amines, such as Aniline, Benzidine, and Paraphenylenediamine. By the use of these compounds, together with the well-known potash test, specific recognition of the lichen acid present is often possible\*.

Asahina has also shown (1934 b) that the crystals of the Potassium salt of three of these Depsidone lichen acids, namely, Salazic acid,  $C_{18}H_{12}O_{10}$ , Salazic acid  $\alpha$ -methyl-ether,  $C_{19}H_{14}O_{10}$ , and Norstictic acid,  $C_{18}H_{12}O_9$ , show a characteristic form when seen under the microscope, by which means the former may usually be distinguished from the latter two compounds. The method employed is to inundate a section of the lichen thallus with a mixture of equal volumes of 20 per cent. Potassium carbonate and 5 per cent. Potassium hydroxide solutions in water. Typical crystals of Potassium salazinate are aggregated in masses of Y- or X-shape, the latter form bearing some resemblance to corn sheaves tied in the middle (fig. 1). Potassium  $\alpha$ -methyl-ether salazinate and Potassium norstictate both form isolated or sparingly crossed narrow acicular crystals (fig. 2). Using material of the species mentioned by Asahina as furnishing characteristic examples of these crystals (*Parmelia saxatilis* for Salazic acid, *Parmelia acetabulum* for Salazic acid  $\alpha$ -methyl-ether or Norstictic acid), I soon discovered that differentiation of these Depsidones by the crystals of their Potassium salts is not always as simple as represented by Asahina. In many cases well-formed crystals of typical appearance are seen under the microscope, but in others the crystallization appears to be imperfect, only short tabular or granular crystals (fig. 3), not referable with certainty to either of the two types figured by Asahina, being produced. In this case only macrochemical analysis could decide the identity of the Depsidone compound present, and for such an analysis abundant material and special laboratory facilities would be necessary. In the chemical investigation of *Neuropogon*-material many such cases of indefinite crystal formation were met with, and it appears that in some species a mixture of two or possibly all of these three Depsidone compounds is present. In all cases the macroscopical reaction with potash is an intense yellow quickly going over into blood-red.

The other type of reaction met with in the genus *Neuropogon* is due to the presence of one or other of two other Depsidone compounds, Protocetraric acid,  $C_{18}H_{14}O_9$ , and Fumar-protocetraric acid,  $C_{22}H_{16}O_{12}$ . These give a more or less pronounced dull to rusty brownish coloration with potash, with Paraphenylenediamine a bright yellow which rapidly turns to a vermilion or miniate-red. If the Depsidone is present in very low concentration, no reaction is perceptible

\* For the benefit of those to whom Asahina's papers are not readily accessible, the following description of the technique involved is given:—0.1 gm. of the pure crystalline Amine (Paraphenylenediamine or Benzidine) is dissolved in 5 c.cm. of absolute alcohol, and the solution applied to the exposed medulla of the lichen to be examined; the colour reaction is usually instantaneous and vivid. It is important that freshly made solution should be employed; the alcoholic Paraphenylenediamine in particular decomposes rapidly, and should not be kept longer than an hour.

with Potassium hydroxide, and the yellow colour first produced by Paraphenylenediamine may tend to persist or to become red only in patches.

By the use of Paraphenylenediamine in conjunction with potash, therefore, it is possible to gain some insight into the actual chemical constitution of the substances elaborated by the thallus, and to employ the knowledge thus obtained in the correlation and delimitation of the taxonomic entities.

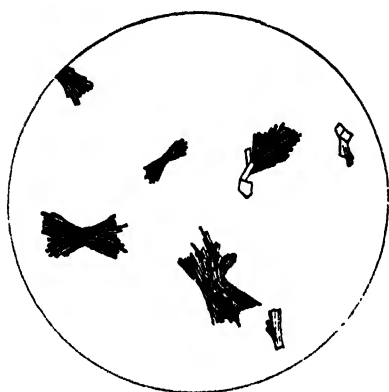


FIG. 1.—Typical crystals of Potassium salazinate.

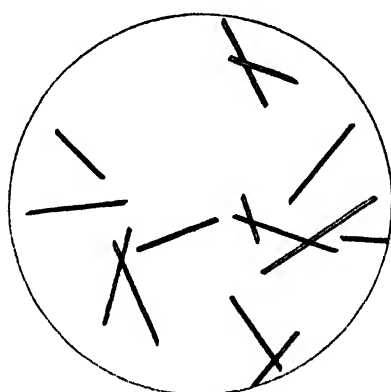


FIG. 2.—Typical crystals of Potassium  $\alpha$ -methyl-ether salazinate or Potassium norstictate.

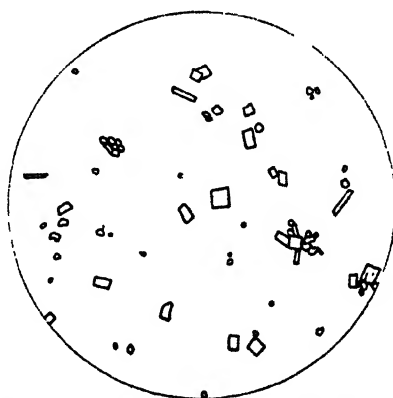


FIG. 3.—Imperfect crystals not referable with certainty to either of the types shown in fig. 1 or fig. 2.

Before commencing this task, however, it is necessary to arrive at some definite conclusion as regards the systematic value to be assigned to chemical differences. As mentioned above, Nylander regarded morphologically indistinguishable, but chemically different, individuals as distinct species, and in this view he has been followed in more recent times by others who have segregated

large numbers of species on the basis of slight differences in the potash reactions produced, often without any conception of the actual chemical differences involved. Asahina (1937) has expressed the opinion that difference in the chemical constituents alone, once established by exact methods, is sufficient for specific segregation, and on these grounds has divided the morphologically monotypic species *Thamnolia vermicularis* into two distinct specific entities, *T. vermicularis* Schaer. emend. Asahina and *T. subvermicularis* Asahina, the former containing Thamnolic acid only, the latter Squamatic and Baeomyceic acids, but no Thamnolic acid. While upholding the principle that chemical difference is in itself a valid specific character, he remarks on the probability of this difference being due to the presence of distinct strains of gonidial algae in the thalli of different individuals. It appears justifiable to assume, when dealing with morphologically identical lichens differing only in their chemical constitution, that the fungal component is the same in both, the chemical contrast being due to distinct assimilatory processes arising from symbiosis with different gonidia.

This assumption that difference in one only of the symbiotic components of a lichen is sufficient basis for specific segregation is, I think, justified by a consideration of the numerous cases wherein differences in the nature of the fungal partner alone have been evaluated as criteria of not only specific, but generic, importance. In the crustaceous lichens, for instance, the genera *Lecidea* and *Catillaria* are separated solely on spore characters, and while Jaag (1928) has demonstrated instances of highly evolved specificity in gonidia of different lichen species and even of different individuals of the same species, it is probable that some species at least of these two genera have as gonidial component the identical strain of alga. This view is borne out by the fact that Weise (1937) succeeded in transplanting gonidia isolated from the thallus of *Parmelia physodes* on to the young purely hyphal podetia of *Cladonia gracilis*, where they were accepted and employed as gonidia. If one were to choose the other alternative, and postulate that genetic difference in both the components of the lichen is necessary for specific segregation, one would be put to the eventual necessity of proving for every known species by cultural experiments that the gonidium was peculiar to that species, and occurred in no other; and if it were shown that, for instance, a species of *Lecidea* and a species of *Buellia* had the same strain of gonidial algae in common, it would be necessary to include one as a variety of the other. The application of this view-point to taxonomic practice would disrupt the entire system of lichenology, and we are left with the alternative of accepting the dictum laid down by Asahina that 'when two morphologically identical lichens show chemically different constituents, they are different species'.

It must be remembered, however, that in many lichens two or more distinct lichen acids are present, and, as Asahina has pointed out (1937), the relative quantities of these substances may vary considerably. It is possible, though not yet



proved, that some morphologically identical species found to contain different lichen acids may actually be the extreme expressions of a gradation from one chemical component through a mixture of both to the other. If, for instance, specimens of *Thamnolia* were eventually found in which all three lichen acids, Thamnolic, Squamatic, and Baeomyceic, were present, it is obvious that Asahina's segregate *T. subvermicularis* would have to be retracted into the other and older species. A gradation in the concentration of the Depsidone present in the medulla is a conspicuous feature of certain of the *Neuropogon*-species here investigated, e.g. the transition from high to low concentration in the *N. aurantiaco-ater* typicus—f. *normalis*—f. *egentissimus* series, and from low to high concentration in the gradation between *N. trachycarpus* typicus and f. *trachycarpoides*. It is convenient for taxonomic purposes to distinguish these easily recognized gradations as forms. In one case, that of *N. melaxanthus*, the only satisfactory explanation which could be found for the variation observed in the crystals of the Potassium salt produced and in the Paraphenylenediamine reaction was that both Salazic acid and Salazic acid  $\alpha$ -methyl-ether (or Norstictic acid) were present in the same thallus in widely varying proportions.

From the foregoing remarks it is obvious that the absence of a characteristic lichen acid in morphologically identical specimens of a normally acid-bearing species cannot be regarded as an important taxonomic difference. In the present paper such acid-free individuals are ranked as forms, or if in addition a slight morphological variation is present, as varieties.

The blue reaction of the medulla with Iodine, a reliable criterion in certain other lichen groups, proved to be of little value in the genus *Neuropogon*. The coloration produced in different individuals was so fluctuating in its intensity that no certain line of demarcation could be drawn between positive and negative reactions.

#### TAXONOMY.

*Neuropogon* was first published as a genus by Nees and Flotow in 'Linnaea,' ix, p. 496 (1835). As Motyka has pointed out, the two species for which it was created, *N. Pöppigii* and *N. antennarius*, are very diverse in structure, and the former has been included by him in a new subgenus, *Protousnea*. Nylander (1860) omits *N. Pöppigii* from the genus *Neuropogon*, removing it to a new genus, *Chlorea*. In *Neuropogon* as thus emended by him he includes two species, *N. melaxanthus* and *N. Taylora*. The former he has confused with two other species, *N. sulphureus* and *N. aurantiaco-ater*, and his description is hence composite. The important point, however, is that all the species included by him in the genus *Neuropogon* are now considered as characteristic of the genus, or subgenus, and as the former it may therefore be considered as having been emended by Nylander.

As mentioned before, there is a division of opinion on the taxonomic status which should be accorded to this group. Du Rietz (1926) and Motyka (1936)

regard it as a subgenus of *Usnea*; Lynge (1937) considers it to be generically distinct on grounds of structure. Although in many respects transitions into the *Eu-Usnea* section undoubtedly occur, the well-known yellow and black variegation of the thallus, together with the usually black apothecial disk seem to afford sufficient grounds for generic segregation. The distribution of the species also points to the probability of descent from a common ancestral stock. Having regard to this evidence, it has been thought proper to retain the generic status of *Neuropogon* in the following treatment.

A feature which may eventually confirm this view is the structure of the pycnoconidial apparatus. In three species at least of *Neuropogon* the fulcra are of the endobasidial type, as defined by Steiner (1901). Lauder Lindsay (1859) has figured them in *N. melaxanthus* and *N. Taylora*, and I have found similar endobasidial fulcra in a specimen of *N. aurantiaco-ater* f. *egentissimus*. It is possible that this type of pycnidial structure is common to the whole genus. Unfortunately very few data are available regarding the pycnidial fulcra in the genus *Usnea* (subgenus *Eu-Usnea* of Motyka). Lindsay (loc. cit.) shows endobasidial fulcra in '*Usnea barbata* Fr.', but omits to mention the origin of the material used, so that the identification is extremely doubtful. Fulcra of the exobasidial type certainly occur in some species of *Usnea*, as reference to the description and figure 120 in Zahlbruckner's 'Lichenes' (1926) will show. Motyka unfortunately does not make any mention of the structure of the pycnoconidial apparatus in the groups considered by him as subgenera of *Usnea*.

*The type-species.*—*Neuropogon antennarius* Nees & Flot., one of the two species upon which the genus *Neuropogon* was originally founded, is, according to Motyka (1936), identical with *N. aurantiaco-ater* (Jacq.). The latter species, as stated above, was included by Nylander in the genus as emended by him, although confused with two other species and listed under the name of *N. melaxanthus*. If we regard Nylander as the authority for the genus in its emended delimitation here accepted, it is obvious that the type-species is *N. aurantiaco-ater* (Jacq. emend. Mot.) M. Lamb, which constituted part of the generic grouping in both its original and its emended form. Motyka (op. cit.) regards *N. melaxanthus* as the type-species of *Neuropogon* as a subgenus of *Usnea*, but gives no reasons for this decision.

*Generic description.*—*Thallus* springing from a basal holdfast, fruticulose, upright or subdecumbent, more or less branched, with or without lateral cilia (fibrillae); branches terete, occasionally angular but never flattened, smooth, minutely scabrid, verruculose, plicate-verruculose, plicate or foveolate, glabrous; in colour yellow or greenish yellow (darkening in herbarium), more or less variegated with black, often in the form of annulations. *Cortex* nubilated with yellowish granules, and formed of indistinct reticulate anastomosing pachydermatic hyphae. *Medulla* loose and subarachnoid or (more commonly)

compact, white, in some species becoming pink with age, KHO+ or —, Pd+ or —. *Central axis* 1/3 to 2/3 diameter of branch in thickness, hard, tenacious, opaque or corneous, cylindrical or slightly irregular in outline, solid or rarely split into two or more strands; formed of closely compacted longitudinally parallel pachydermatic hyphae. *Isidia* absent. *Soredia* present or absent; when present, borne on the branches in rounded or irregular soralia, concave-eroded to convex-pulvinate, pulverulent or granular-compacted, yellow to blackish. *Apothecia* (when present) borne laterally on the thallus-branches\*, lecanorine, with smooth, verruculose, plicate-verruculose, or plicate *excipulum* concolorous with the thallus, with or without marginal cilia. *Disk* black or brown-black, rarely brownish flesh-coloured, reddish or greenish black, matt or subnitid, not pruinose. *Hypothecium* colourless or faintly yellowish. *Hymenium* colourless in lower part, blue-green or brownish above, often with a yellowish granular epithecium. *Spores* 8, simple, ellipsoid to subglobose, colourless. *Pycnidia* (when present) immersed in the terminal branches, often causing irregular swellings; more or less spherical, with colourless perifulcrum; *fulcra* (as far as observed) endobasidial; *pycnocnidia* (as far as observed) staff-shaped, straight, sometimes with a slight excentric swelling.

*Artificial key to all known species.*

1 a. Thallus sorediate.

- 2 a. Medulla lax, KHO—, Pd—; axis comparatively thin; soralia commonly convex-pulvinate (but in Southern Hemisphere specimens often eroded, as in *N. antarcticus*) ..... *N. sulphureus*.

- 2 b. Medulla compact, its reaction with KHO or Pd either positive or negative; soralia often concave-eroded, sometimes convex-pulvinate.

- 3 a. Thallus branches subnitid, smooth or slightly foveolate (in *N. acromelanus* var. *inactivus* f. *scabridulus* with minute black papillae visible only under  $\times 10$  lens, but never with large verruculae or sharp rugosities).

- 4 a. Thallus branches not foveolate, devoid of paler yellow patches, usually with black-edged annular transverse cracks; medulla KHO+ yellow then red, Pd+ yellow (in the typical form and var. *decipiens*), or KHO—, Pd— (in var. *inactivus*) ..... *N. acromelanus*.

- 4 b. Thallus branches slightly foveolate, more or less mottled with paler yellow patches, with few or no black-edged annular cracks; medulla KHO+ brown, Pd+ yellow then miniate red ..... *N. insularis*.

- 3 b. Thallus branches verruculose or plicate-rugose, commonly matt, devoid of annular black-edged cracks; medulla KHO—, Pd— (in the typical form), or KHO+ brown or —, Pd+ yellow then miniate red or persistently yellow (in f. *sorediifer*) ..... *N. antarcticus*.

\* Apparently never terminal, as stated by Nylander and Motyka; a small offshoot representing the original branch apex is constantly present on the under side of the excipulum.

- 1 b. Thallus not sorediate.
- 5 a. Margin of apothecia without fibrillae.
- 6 a. Thallus branches smooth, sparingly branched, not verruculose (although in *N. Taylora* commonly with slightly swollen paler yellow patches).
- 7 a. Thallus with black-edged annular cracks; medulla KHO+ yellow then blood-red, Pd+ yellow (in the typical form), or KHO—, Pd— (in var. *subpolaris*) ..... *N. ciliatus*.
- 7 b. Thallus devoid of black-edged annular cracks; medulla KHO—, Pd—.
- 8 a. Plant large, robust (6–9 cm.); usually mottled with paler yellow slightly raised irregular patches. .... *N. Taylora*.
- 8 b. Plant small (not over 3 cm.), with subcornute branches. .... *N. perpusillus*.
- 6 b. Thallus branches verruculose or rugose-verruculose, or occasionally rugose-plicate.
- 9 a. Medulla KHO+ brownish, Pd+ yellow then miniate red (in the typical form), or KHO—, Pd+ yellow then miniate red (in f. *normalis*), or KHO—, Pd— (in f. *egentissimus*) ..... *N. aurantiaco-ater*.
- 9 b. Medulla KHO+ yellow then blood-red, Pd+ yellow or orange.
- 10 a. Plant small, about 3 cm. high, more or less densely fibrillose ..... *N. aurantiacus*.
- 10 b. Plant larger, 5–10 (–12) cm. high, not densely fibrillose ..... *N. melananthus*.
- 5 b. Margin of apothecia furnished with numerous fibrillae.
- 11 a. Medulla KHO— or faintly reddish or blood-red, Pd+ yellow or orange-yellow.
- 12 a. Disks of apothecia yellowish to reddish brown, becoming black only by degeneration.
- 13 a. Plant small (seldom above 4 cm.); apothecia up to 7.5 mm. diam.; marginal cilia of excipulum subcapillary (0.1–0.3 mm. thick), entirely black or nearly so; medulla KHO— or + yellow then faintly reddish, Pd+ yellow (in the typical form), or KHO+ yellow then blood-red, Pd+ orange-yellow (in f. *trachycarpoides*) ..... *N. trachycarpus*.
- 13 b. Plant large (6–9 cm.); apothecia up to 15 mm. diam.; marginal cilia of excipulum coarse (0.3–0.5 mm. thick), variegated with black and yellow in about equal proportions; medulla KHO+ yellow then blood-red, Pd+ yellow or orange-yellow. .... *N. substrigulosus*.
- 12 b. Disks of apothecia black or greenish black, never yellowish or brown. Thallus branches smooth, subnitid, with black-edged annular cracks ..... *N. ciliatus*.
- 11 b. Medulla KHO+ faintly yellow or —, Pd+ yellow then miniate red; plant loosely straggling, large (up to 10 or 12 cm.), fibrillose (in the typical form) or without fibrillae (in f. *subciliatus*) ..... *N. strigulosus*.

## DESCRIPTION OF THE SPECIES, VARIETIES, AND FORMS.

*Stirps N. sulphurei (spp. 1 & 2).*

1. *N. SULPHUREUS* (Koenig) *Hellbom*, in *Bihang till Kgl. Svensk. Vet.-Akad. Handl.* XXI, afd. 3, no. 13, p. 21 (1896).

*Synon.*—*Lichen sulphureus* Koen., apud Olafsen & Povelsen, *Reise igion. Island*, app. p. 16 (1772), first edition not seen. *Lichen pallidus* Retz., *Fl. Scand. Prodr.* p. 234 (1779). *Usnea sphacelata* R. Br., *Suppl. to the Append. to Capt. Parry's Voyage*, p. cccvii (1824), first edition not seen. *Neuropogon melaxanthus* Nyl. in *Mém. Soc. Imp. Sci. Nat. Cherbourg*, III, p. 170 (1855), non semper alibi ! \* *Usnea sulphurea* Th. Fr. in *Kgl. Svensk. Vet.-Akad. Handl.*, VII, no. 2, p. 9 (1867). *Neuropogon melaxanthus f. sulphurea* Hue, in *Nouv. Archiv. du Muséum, sér. 3, II*, p. 272 (1890).

*Icon.*—Pl. 5, fig. 4 (specimen from S. America, Ecuador, Pichincha volcano, coll. Jérémie, in *Herb. Mus. Brit.*). Further : Elenkin, in *Mém. Acad. Imp. Sci. Nat. St.-Pétersbourg, classe Phys.-math.*, XXVII, tab. i, fig. 6 (1909).

*Exsicc.*—Th. Fries, *Lich. Scand.* no. 51.—Elenkin, *Lich. Fl. Rossiae*, no. 113 a & b.—Krypt. *Exsicc. Vindob.*, no. 3070.—Zahlbruckner & Redinger, *Lich. rar. exsicc.*, no. 384.

This, the only species of *Neuropogon* known to occur in the Northern Hemisphere, is too familiar to require further description ; it is easily recognized and quite monotypic (except for the S. American f. *acanthella*), both morphologically and chemically, with the medulla invariably KHO—, Pd—. Soralia are well developed, convex and pulvinate (except in a few instances mentioned later), and almost always blackish. One of its most striking and constant characters is the lax, almost arachnoid nature of the medulla, a condition found in no other known species of *Neuropogon* with the exception of *N. trachycarpus*, in which the medulla is occasionally somewhat loose, also *N. aurantiacus*, according to Motyka.

Apothecia have never been observed.

*Usnea sphacelata* R. Br., the type-specimen of which is present in the British Museum Herbarium, is typical *N. sulphureus*. The name has more than once been applied in literature on Antarctic lichens to other species of *Neuropogon*.

*N. sulphureus* attains its maximum development in the Arctic regions ; it is common in Ellesmere Land, Greenland, Iceland, Jan Mayen, Spitsbergen, and Franz Joseph Land, but apparently becomes rare in Novaya Zemlya. It is entirely absent, it seems, from the European continent (see Lyngé in *Svensk Bot. Tidskr.*, XXVI, p. 411 ; 1932). In NE. Greenland it ascends to 1,350 metres above sea-level, according to Lyngé. Motyka (1936) has established the fact that this species occurs also in the Southern Hemisphere, at high altitudes along the Andean chain. To the localities enumerated by him (op. cit.) the following,

\* See footnote on p. 225.

from collections in the British Museum Herbarium and at Kew, may be added : Ecuador, Chimborazo, 16,600–16,700 feet, leg. Whymper ; Ecuador, Antisana, 16,000 feet, leg. Whymper ; locality illegible, most probably also in Ecuador, 15,871 feet, leg. Whymper ; Ecuador, Quito, altitude not stated, leg. Jameson ; Bolivia, prov. Larecaja, near Sorata, Rampe de l'Apacheta, 4,500 metres, leg. Mandon, 1857 (Mandon, Pl. Andium Boliviensium, no. 1737) ; Peru,

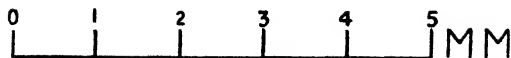
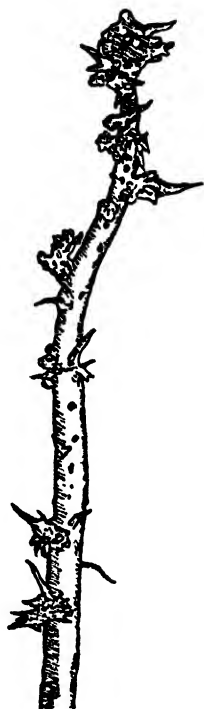


FIG. 4.—An ultimate branch of the type-specimen of *Neuropogon sulphureus* f. *acanthella* M. Lamb, showing the spinulose outgrowths from the soralia.

Azangaro, altitude not stated, leg. Lechler, 1854 ; Peru, Puno, San Antonio de Esquilache, 15,500 feet, on andesite rocks, leg. Dora Stafford, 1937 (no. 762) ; South America, no exact locality or altitude stated, name of collector illegible, ex. herb. G. J. Lyon. To these records must be added two others of exceptional interest, one of which is, however, somewhat doubtful ; Antarctic regions, South Victoria Land, leg. Borchgrevink's *Southern Cross Expedition*, 1900 ;

and Snow Hill, 64° 30' S. lat., leg. Ekelöf, Svenska Sydpolar-expeditionen, 1901-3, determined by Darbishire as '*Neuropogon melaxanthum*'. The former specimen is certainly *N. sulphureus*, agreeing in all respects with the Arctic form, except that the soralia are eroded, as they are also in some of the S. American specimens cited above. The Snow Hill specimen is unfortunately an old degenerated plant, with lax medulla and a few blackened convex soredia, and probably belongs here, but is not determinable with certainty. These records are of considerable interest, since they raise the question as to whether *N. sulphureus* may not be a truly bipolar species showing linkage north and south through the American continents. It is a pity that so few lichen collections have been made in the Rocky Mountains of Canada; it would not be surprising to find *N. sulphureus* from high altitudes in these regions, in view of its occurrence in the Andes.

Forma ACANTHELLA *M. Lamb*, f. nov.

*Diagn.*—Soralia pro maxima parte coeuntia ac cornua minuta spinulosa emittentia. Medulla valde laxa, ut in typo.

*Icon.*—Fig. 4 (portion of an ultimate branch).

Soralia for the most part not pulverulent, but to a great extent healed over, and as such much less obvious than in the typical form. Most of the healed-over soralia have erupted several tiny cornute-spinulose yellow processes up to 0.5 mm. in length, which in appearance remind one of the 'roestelia'-aecidia of the rust-fungus *Gymnosporangium*, and give the branches a very spinulose appearance. The specimen is sterile, and some tufts, in which the soralia are almost entirely healed over, might at first sight be confused with small sterile plants of *N. aurantiaco-ater*, were it not for the extremely lax arachnoid medulla.

Based on a specimen from Peru, prov. Carabaya, above Limbani, 14,500 feet, on face of slate rock, leg. Dora Stafford, 1937 (no. 1108), and preserved in the British Museum Herbarium.

2. *N. ANTARCTICUS* (*Du R.*) *M. Lamb*, comb. nov.

*Synon.*—*Usnea antarctica* Du Rietz in Svensk Bot. Tidskr., xx, p. 93 (1926). *Usnea sulphurea* var. *granulifera* Wainio\*, Rés. Voy. S.Y. *Belgica*, Lichens, p. 11 (1903). *Usnea melaxantha* var. *granulifera* Hue, Deux. Expéd. Antarct. Franc. (1908-1910), Lichens, p. 27 (1915), e. descript. *Usnea granulifera* Motyka, Lich. Gen. Usn. Stud. Monogr., i, p. 35 (1936), pro parte.

*Icon.*—Pl. 6, fig. 9 (specimen in Herb. Mus. Brit. from the classical locality, South Victoria Land, leg. Borchgrevink's *Southern Cross* Expedition, 1900); fig. 8 (three plants from the South Shetlands); Pl. 11, fig. 26 (specimen from W. Graham Land, Galindez Island); Pl. 6, fig. 10 (portion of the type-specimen of '*Usnea sulphurea* var. *granulifera*' Wain., the fruiting condition, three times natural size). Further: Wainio, Rés. Voy. S.Y. *Belgica*, Lichens, tab. iii,

\* The names adopted by this author at different dates are: 1876-9, E. Lang; 1880-1919, E. Wainio; 1920-9, E. Vainio.

fig. 19 (1903). (On the plate itself erroneously named *U. sulphurea* var. *sorediifera* (Cromb.) Wain.)

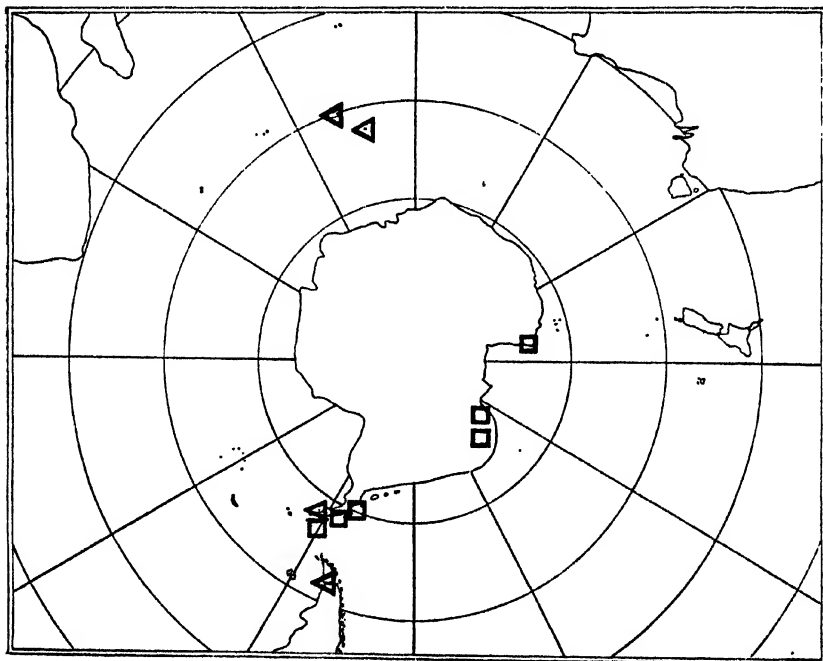
I have not seen the type-specimen of this species, but the description given by Du Rietz (loc. cit.) makes it clear that it is the same as another plant in the British Museum Herbarium from the same locality, collected also by the *Southern Cross Expedition*. This plant is shown in Pl. 6, fig. 9.

*N. antarcticus* is perhaps the most protean and variable species of the whole genus. Du Rietz, in his original key (op. cit. p. 91), separated this species from the closely allied *N. sulphureus* by the character of the soralia: globose or subglobose, well defined, dark in *N. sulphureus*, and plane or slightly concave, often  $\pm$  confluent, commonly pale in *N. antarcticus*. Actually, however, as study of more material has shown, none of these soredial characters is sufficiently constant to be used for delimitation of the two species. The three plants shown in Pl. 6, fig. 8 formed part of the same collection from Deception Island, South Shetlands, received from the British Graham Land Expedition of 1934-7; from below to above they form an intergrading series of variation in the form of the soredia. But for the presence of the connecting-links, one might well be tempted to regard plants of the extreme types as distinct varieties or even species.

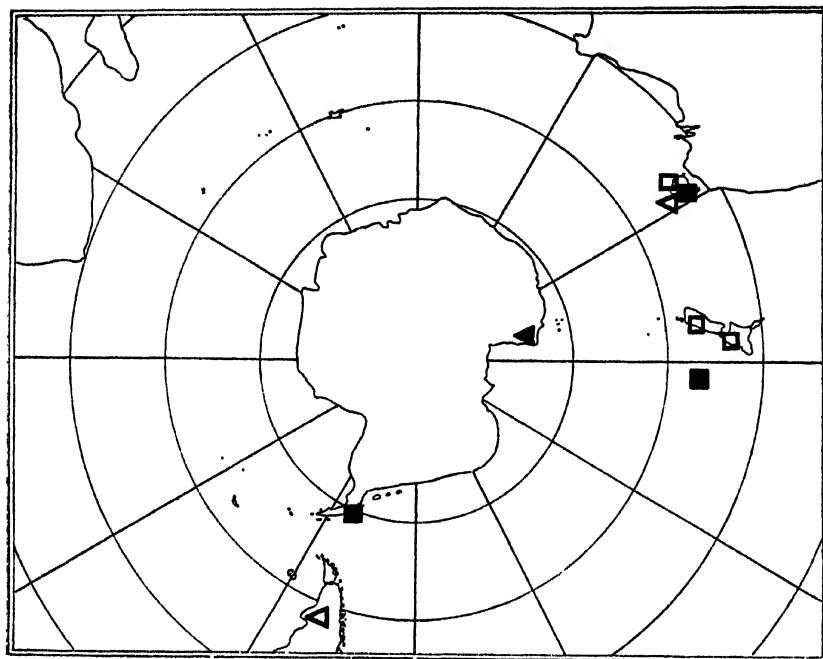
Motyka (loc. cit.) has separated Wainio's '*Usnea sulphurea* var. *granulifera*' as a proper species, including Crombie's '*Neuropogon melaxanthus* var. *sorediifer*'. I am unable to agree with this; the type-specimen of the former, which I saw at Turku, and part of which is shown in Pl. 6, fig. 10, is in my opinion undoubtedly *N. antarcticus* in the fruiting condition. According to Motyka, the chief difference lies in the papillate nature of the thallus branches in '*Usnea granulifera*'. But Du Rietz, in his original description of *N. antarcticus*, wrote: 'Thallus . . . dense papillosus vel sublaevis', and the specimen from the same locality represented in Pl. 6, fig. 9 has extremely papillate branches. Like the soralia, the amount of papillation is extremely variable, and unsuitable as a taxonomic criterion.

The habit, surface, and colouring of the thallus is also prone to much variation. The typical form is more or less erect (Pl. 6, fig. 9 and Pl. 11, fig. 26). A great deal of the material seen by me from the S. American sector of the Antarctic consists of subdecumbent individuals, such as represented on Pl. 6, fig. 8. There is, however, no sharp dividing-line in this respect, nor is there in regard to the nature of the surface and coloration of the bands on the thallus branches; plants of the typical form commonly have a slightly glistening surface as seen under a  $\times 10$  lens, while subdecumbent individuals are for the most part completely matt. Some of the latter, however, have subnitid branches. Again, the upright form has commonly purple markings where the annulations are less intense; these purple markings are usually absent in the subdecumbent or matt forms, but present in some. Of the other characters, soralia, chemical reactions, and thallus anatomy afford also no indication of any true systematic differences within the widely ranging circle of forms composing this species.





MAP 1.—Distribution in the Antarctic of *Neuropogon antarcticus* (squares) and *f. sorediifer* (triangles).



MAP 2.—Distribution in the Antarctic of *Neuropogon acromelanus* (white squares), *var. decipiens* (black squares), occurrence in Peru omitted), *var. inactives* (white triangles), and *var. inactives f. picatus* (black triangle).

Apothecia appear to be very rare in *N. antarcticus*; I have seen them only in two specimens. One of these, no. 360 in Herb. Vainio, from Auguste Island in the Gerlache Channel, is shown in Pl. 6, fig. 10. The other specimen was collected on Galindez Island in the Argentine group\* by the British Graham Land Expedition. So far as one can judge from these two occurrences, the apothecia are similar to those of *N. aurantiaco-ater* or *N. melaxanthus*—eciliate, with the excipulum ranging from slightly papillose to papillate-rugose, the disk brown-black to black. In the Galindez Island specimen I found the hymenium to be 60–100 $\mu$  high, irregularly dull yellow-greenish in its upper part, a slight yellowish granular epithecium being present. Spores 8, very broadly ellipsoid or subglobose, 8–10 by 7–8 $\mu$ , colourless or faintly yellow greenish, with distinct wall about 1 $\mu$  thick.

The chemical reactions of the medulla with KHO and Pd, except in the following form, are constantly negative. Wainio's type-specimen of '*Usnea sulphurea* var. *granulifera*' is also KHO—, Pd—.

'*Neuropogon Taylori*, Nyl.' in Blackman, Lichenes, in Rept. Coll. Nat. Hist. Southern Cross, p. 320 (1902), is partly *N. antarcticus* and partly *N. sulphureus*.

The type-specimen of *N. antarcticus* was collected in South Victoria Land, in the Australian sector of the Antarctic. Dodge and Baker have recently reported it also to the east of the Ross Sea, in Marie Byrd Land, and King Edward VII Land (Ann. Missouri Bot. Gard., xxv, p. 603; 1938). In the S. American sector there can be no question as to its abundance; I have seen material from the South Shetlands, the Palmer Archipelago, the Berthelot group, and the Argentine Islands, and in Herb. Vainio from Auguste Island in the Gerlache Channel (as '*Usnea sulphurea* var. *granulifera*'). The material recorded by Hue in Deux. Expéd. Antarct. Franç. (1908–10), Lichens, p. 27 (1915), as '*Usnea melaxantha* var. *granulifera*' undoubtedly belongs here also; it is listed from the South Shetlands (Deception Island), Booth-Wandel Island, Petermann Island, and Marguerite Bay. It hence seems to be abundant all down the west coast of Graham Land. Apparently it is a circumpolar eu-Antarctic species; its known distribution is shown in Map 1.

**Forma SOREDIIFER** (Cromb.) *M. Lamb*, comb. nov.

*Synon.*—*Neuropogon melaxanthus* var. *sorediifer* Crombie in Journ. Linn. Soc. Lond., Bot. xv, p. 182 (1876). *Usnea melaxantha* var. *sorediifera* Müll.-Arg. in Journ. Linn. Soc. Lond., Bot. xxxii, p. 200 (1896), dubia. *Usnea sulphurea* var. *normalis* Wainio, Rés. Voy. S.Y. Belgica, Lichens, p. 11 (1903), pro min. parte. *Usnea granulifera* Motyka, Lich. Gen. Usn. Stud. Monogr., i, p. 35 (1936), pro parte.

*Icon.*—Pl. 6, fig. 12 (the type-specimen from Kerguelen, Royal Sound, leg. Eaton, Venus Transit Expedition, in Herb. Mus. Brit.).

\* The Argentine group referred to in this paper is that on the west coast of Graham Land, near Cape Tuxen, and not the group of the same name off the eastern coast of Louis Philippe Land.

This form differs from the typical species only in containing Protocetraric acid or Fumar-protocetraric acid in greater or less quantity. The reactions of the medulla are therefore  $\text{KHO} +$  brownish or  $-$ ,  $\text{Pd} +$  yellow then miniate red or in some cases persistently yellow. The type-specimen from Kerguelen and a specimen in the British Museum Herbarium from the Magellan Straits, Mount Aymond, are rich in this compound, and give the former type of reaction; in some specimens from the South Shetlands, Deception Island, collected by the British Graham Land Expedition, the reactions are:  $\text{KHO} -$ ,  $\text{Pd} +$  persistent yellow. Protocetraric acid and Fumar-protocetraric acid have been observed by Asahina (Acta Phytochim., VIII, p. 50; 1934) to produce a yellow then red coloration with  $\text{Pd}$ , and the persistently yellow reaction is apparently dependent on the lesser quantity of the compound present. A similar reaction was observed in an individual of *N. aurantiaco-aler* f. *normalis* very poor in lichen acid; the  $\text{Pd}$  reaction was yellow, with the later development of a few red specks where the substance was more concentrated. It is possible that the Deception Island specimens may contain Psoromic acid, but in view of the foregoing remarks and the absence of any yellow reaction with potash, this does not appear probable.

It is uncertain whether the specimens enumerated by Hue in Expéd. Antarct. Franç. (1903-5), p. 4 (1908), belong here. He writes (op. cit. p. 5): 'Sous l'action de la potasse, cette couche gonidiale ainsi que la base du cortex jaunit puis rougit légèrement'. This may have been due to Protocetraric or Fumar-protocetraric acid in the medulla or to the browning of the gonidia caused by the application of potash. Wainio's record of '*Usnea sulphurea* var. *sorediifera*', from the Gerlache Channel, in Rés. Voy. S.Y. *Belgica*, Lichens, p. 11 (1903), does not refer to this plant, but to *N. acromelanus* var. *decipiens*.

The f. *sorediifer* appears to attain its optimum development in the sub-Antarctic regions—Kerguelen and the Magellan district, also Heard Island, according to Zahlbruckner, in Deutsche Südpolar-Expedition 1901-3, Die Flechten, VIII, p. 52 (1906). The specimens collected in the South Shetlands by the British Graham Land Expedition appear to represent a somewhat depauperate state, probably at or near the southernmost limit of the acid-bearing form's distributional area. They were growing intermixed with the typical form, a fact which favours the view that such acid-bearing plants deserve systematic differentiation.

*Stirps N. Taylori (spp. 3 & 4).*

3. *N. TAYLORI* (Hook. fil.) Nylander, Synops. Lich. I, p. 273 (1860).

*Synon.*—*Usnea Taylori* Hook. fil. apud Hooker & Taylor in Lond. Journ. Bot. III, p. 657 (1844). *Alectoria Taylori* Nyl. in Mém. Soc. Imp. Sci. Nat. Cherbourg, v, p. 98 (1857).

*Icon.*—Pl. 8, fig. 16 (type or syntype specimen in Herb. Mus. Brit.). Further:—Hook. fil. & Ch. Babington, Bot. Antarct. voyage *Erebus* and *Terror*, I, Flora

Antarctica, pt. 2, pl. cxcv, fig. i (1847). Lindsay in Trans. Roy. Soc. Edinb. xxii, pl. iv, figs. 12-16 (1859). Reinke in Pringsheim, Jahrbüch. f. wiss. Bot. xxviii, pp. 396-7, figs. 116 & 117, iii.

Known with certainty only from Kerguelen, where it appears to be of common occurrence on the basaltic rocks. It is a very uniform and easily recognized species, characterized externally by its infrequent branching and thick smooth cortex, which is usually mottled with lighter yellow patches.

Apothecia usually present, eciliate, with smooth excipulum (not verrucose, as described by Motyka, Lich. Gen. Usn. Stud. Monogr. i, p. 27 (1936)).

All the material which I have seen gives negative reactions of the medulla with KHO and Pd. The central axis is extremely thick, sometimes slightly brownish, often excavated in the centre and with a variously corrugated outline; one or more smaller independent strands may be formed by abstriction of these folds, and are then separated from the main axis by the looser medullary tissue. This is shown in Reinke's illustration (loc. cit.).

Räsänen (Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, ii, no. 1, p. 10; 1932) lists this species from W. Fuegia, Mount Buckland, and, in Revista Universitaria, xxi, p. 140 (1936), from S. Central Chile, prov. Cautin. These records are of considerable distributional interest.

Hooker, in his original description of this species, remarks: 'This Lichen is the handsomest of the vegetable productions of this the Island of Desolation.'

#### 4. *N. INSULARIS* M. Lamb, sp. nov.

*Diagn.*—Thallus robustus, major (usque ad 8 cm. altus), erectus, parte basali substrato affixus; paulum supra basin dichotome et sympodialiter ramicans, caulibus tantum extremitatibus abundanter ramulosis, ibique tenuibus, acuminatis. Ramuli laterales desunt. Rami teretes, leves, subnitidi, haud verruculosi, passim leviter irregulariter indistincteque foveolati, rarius annulatione nigrata circumscissi, parte basali minute asperuli opacique. Color thalli nunc luteo-fuscescens, tantum ramulis ultimis plus minusve annulatim nigratus, multis in locis maculis variegatus irregularibus planis vel leviter tumidis pallidioribus sulphureis; his maculis apices ramorum versus in soralia abientibus erumpentia erosave plus minusve rotundata vel irregulariter confluentia pulverulenta sulphurea. Cortex 100-120  $\mu$  crassus, flavidus, e hyphis pachydermaticis anastomosantibus parum distinctis, zona exteriori 8-10  $\mu$  crassa amorphia hyalina obtectus. Medulla crebra, alba, gonidia irregulariter disposita continens. Axis crassus (circ.  $\frac{1}{2}$  diametri ramorum), solidus vel in centro leviter stellatim excavatus, subcorneus, fuscidulus.

Medulla KHO+ fuscescens, Pd+ flava deinceps miniato-rubescens. [Apothecia desunt; pycnidia non visa.]

*Loc.*—Prince Edward group: Marion Island\*, leg. Challenger Exped., 1873. Type-specimen in Herb. Kew. Another but somewhat imperfect specimen,

\* Lat. 46° 49' S., Long. 37° 49' E.

probably from the same collection, is present in the British Museum Herbarium.

*Icon.*—Pl. 8, fig. 17 (the type-specimen).

Habitually this species shows an unmistakable affinity with *N. Taylora*, the irregular paler sulphur-yellow patches in particular being common to both. In section these patches, in the basal parts of the thallus at least, are corticate, their cortex differing from that of the rest of the thallus in being heavily nubilated with yellowish granules. Towards the ends of the branches they become more erumpent and pulverulent, and are gradually converted into well-developed soralia. The medullary reactions indicate the presence of Protocetraric or Fumar-protocetraric acid.

The specimen in the British Museum Herbarium is listed by Motyka (Lich. Gen. Usn. Stud. Monogr. 1, p. 37; 1936) under '*Usnea granulifera*', with the remark: 'habitu leviter recedens'. Although the chemical constitution is the same as that met with in *N. antarcticus* var. *sorediifer*, the morphological characters make it clear that it is not related to that species, but to *N. Taylora*.

*Stirps N. ciliati (spp. 5 & 6).*

5. *N. CILIATUS* (Nyl.) *Krempelhuber* in Verhandl. Zool.-Bot. Ges. Wien, XVIII, p. 313 (1868).

*Synon*—*Neuropogon melaxanthus* var. *ciliatus* Nyl. in Journ. Linn. Soc. Lond., Bot. IX, p. 245 (1865). *Usnea melaxantha* var. *ciliata* Mull.-Arg. in Comptes-rend. Soc. Roy. Bot. Belge, XXXI, part 2, p. 26 (1892). *Usnea ciliata* Du Rietz in Svensk Bot. Tidskr., XX, p. 91 (1926). *Usnea sulphurea* var. *sphacelata* Wainio, Rés Voy. S.Y. Belgique, Lichens, p. 12 (1903), non *Usnea sphacelata* R. Br.!

*Icon.*—Pl. 5, fig. 1 (specimen in Brit. Mus. Herb. from New Zealand, coll. Sinclair; probably syntype material); Pl. 7, fig. 13 (specimen in Herb. Vainio from Tierra del Fuego). Further:—Lindsay in Trans. Linn. Soc. Lond. XXV, pl. lxi, fig. 27 (1866), somewhat doubtful.

An easily recognized species characterized by the smooth subnitid wax-like surface of the branches, the absence of soredia, and the black-edged annular cracks in the cortex. These cracks are an almost constant feature of both this species and *N. acromelanus*, although usually less obviously developed in the latter.

The specimen shown on Pl. 5, fig. 1 is one in the British Museum Herbarium from the classical locality, New Zealand, Nelson Mountain, coll. Sinclair, and is probably part of the original gathering. The medulla gives with potash a yellow then blood-red reaction, not simply 'lutescens', as stated by Motyka in Lich. Gen. Usn. Stud. Monogr., I, p. 26 (1936); with Pd a persistent golden-yellow coloration is produced. Under the microscope the crystals of the Potassium salt formed in alkali solution were for the most part of the indefinite almost granular type, not referable with certainty either to Potassium salazinate

or to Potassium  $\alpha$ -methyl-ether salazinate (or Potassium norstictate). Perhaps, as suspected in the case of *N. melaxanthus*, both Depsidone compounds occur side by side in the same thallus.

Motyka (loc. cit.) states that *N. ciliatus* is confined to New Zealand, but examination of the plants of the Belgian Expedition in Vainio's herbarium showed that no. 188, pro parte, listed by Wainio in Rés. Voy. S.Y. *Belgica*, Lichens, p. 12 (1903) as '*Usnea sulphurea* var. *sphacelata*', is a beautifully developed specimen of this species (Pl. 7, fig. 13). It was collected in Tierra del Fuego, Beagle Channel, west of Lapataia Bay. Thus one more species is added to the number known to have bicentric distribution in New Zealand and southernmost S. America. The medulla of the Fuegian plant gives the reactions: KHO+ yellow then blood-red, Pd+ orange-yellow. Wainio (loc. cit.) had recognized it as identical with *N. ciliatus*, but confused the latter species with *N. sulphureus* (*Usnea sphacelata* R. Br.). The verruculae stated by him in his description to occur on some of the branches belong to an epiphytic sterile crustaceous lichen clothing the basal parts of the thallus.

The specimens from Fuegia mentioned by Räsänen (in Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, II, no. 1, p. 10; 1932) as '*Usnea sphacelata*' are not likely to be *N. ciliatus*, as the thallus is described as verruculose and reticulate-rugose.

*N. ciliatus* is often fertile; the apothecia are up to 7 mm. diam., the disk black, occasionally with a verdigris-green tinge. The excipulum is either smooth, as stated by Motyka, or with anastomosing plications. Nylander, in his original description (loc. cit.), states: 'receptaculo (vel margine) ciliis nonnullis munito'. Such excipular cilia may be present or absent in *N. ciliatus*. I have seen a specimen in the Kew Herbarium from New Zealand, exact locality not stated, coll. C. Knight, in which each apothecium was furnished with a variable number (3-12) of acuminate blackened cilia 1-9 mm. in length. I am not inclined to attach much systematic importance to their occurrence; Müller Argau (loc. cit.) states that eciliate and ciliate apothecia may occur in the same tufts.

Var. SUBPOLARIS *M. Lamb*, var. nov.

*Diagn.*—Minor (usque ad 3.5 cm.), subdecumbens, parce ramosus, ramis primariis sulphureis vel irregulariter nigratis, ramis ultimis nigro-variegatis; medulla KHO—, Pd—. Ceterum ut in forma typica speciei. [Sterilis.]

*Icon.*—Pl. 5, fig. 7 (the type-material; nomenclatural type on the left; on the right an older specimen).

Here belong three specimens from South Victoria Land, Cape Sastrugi, Evans Cove, collected by the British Antarctic (*Terra Nova*) Expedition of 1910, and now in the British Museum Herbarium. They form part of the material recorded as '*Neuropogon melaxanthum*' by Darbishire (in Brit. Antarct. *Terra Nova* Exped., Bot., pt. 3, p. 32; 1923) and as '*Usnea antarctica*' by Motyka (in Lich. Gen. Usn. Stud. Monogr. I, p. 24; 1936).

The plants present a very windswept appearance, lying closely appressed to the rocks on which they were growing. The texture of the thallus surface under the lens is smooth and wax-like, as in the typical form, and the characteristic black-edged annulations, although not obvious, are by no means rare. Aged specimens (Pl. 5, fig. 7, on the right) lose their finer branches, and have a coarsely depauperate appearance.

This extension into the eu-Antarctic regions of an otherwise sub-Antarctic species is comparable to that found in *N. acromelanus* (see p. 220).

6. *N. ACROMELANUS* (Stirt.) *M. Lamb*, comb. nov.

*Synon.*—*Usnea acromelana* Stirton in Trans. & Proc. New Zealand Instit. xxx, p. 388 (1898).

*Icon.*—Pl. 11, fig. 27 (part of the type-specimen in Herb. Mus. Brit.).

It might, as Motyka points out (in Lich. Gen. Usn. Stud. Monogr. I, p. 24; 1936), almost be regarded as a sorediate form of *N. ciliatus*, with which it has the characteristically 'waxy' thallus surface and black-edged annular cracks of the cortex in common. The typical forms of the two species also coincide in their chemical reactions (KHO+ yellow then blood-red, with formation of crystals under the microscope; Pd+ golden-yellow). *N. acromelanus* is, however, in its typical form, less or often not at all darkened towards the apices of the branches, and this difference, together with the constant presence of soralia, makes it easy to distinguish from *N. ciliatus*.

The medulla of the type-specimen, on being treated under the microscope with KHO+  $K_2CO_3$ , produced well-formed acicular crystals characteristic of Potassium  $\alpha$ -methyl-ether salazinate or Potassium norstictate, but a transition to the short broad tabular form of crystal was observed, and hence it is not safe to state that Salazic acid does not also occur in the thallus of this species.

Apothecia unknown.

As mentioned by Motyka (op. cit. p. 25), the type-specimen was recorded as having grown 'on trees'; this is probably a mistake, since Motyka observes that other specimens occur exclusively on rocks.

The species in its typical form is known to occur in New Zealand (both North and South Islands) and Tasmania (Mount Wellington, coll. Mossman, no. 796, 1850, in Herb. Kew). The distribution of this species and its varieties and forms (with the exception of var. *inactivus* f. *scabridulus*) is shown in map 2.

*Key to the varieties and forms of N. acromelanus.*

Medulla KHO+ yellow then blood-red, Pd+ yellow.

- |   |   |
|---|---|
| Plant usually moderate in size (about 6 cm.); only slightly or not at all blackened at the tips of the branches; soralia plane or slightly eroded, usually pale .....                         | [speciei.                               |
| Plant usually smaller (commonly under 3.5 cm., exceptionally up to 6 cm.); branches usually blackened for a considerable part of their length; soralia pulvinate-convex, commonly blackened.. | Forma typica<br>var. <i>decipiens</i> . |

Medulla KHO—, Pd—.

Thallus branches for the most part light-coloured.

Non-sorediate parts of thallus branches seen to be entirely smooth under  $\times 10$  lens. ....

var. *inactivus*.

Non-sorediate parts of thallus branches seen under  $\times 10$  lens to be scabrid with minute blackened papillæ (barely visible to the unaided eye) .....

[f. *scabridulus*.

var. *inactivus*

Thallus branches entirely blackened except for a short distance at the base .....

[f. *picatus*.

var. *inactivus*

Var. *DECIPIENS* M. Lamb, var. nov.

*Diagn.*—Planta vulgo minor (usque ad 3.5 cm., raro ad 6 cm.), ramis plus minusve late nigratis, soraliis pulvinato-convexis, vulgo nigratis; reactionibus aliisque notis cum forma typica congruens.

*Synon.*—*Usnea sulphurea* var. *sorediifera* Wainio, Rés. Voy. S.Y. Belgica, Lichens, p. 11 (1903). Non *Neuropogon melazanithus* f. *sorediifer* Cromb.!

*Icon.*—Pl. 5, fig. 5 (the type-material; nomenclatural type on the left).

At first sight this variety, with its cushion-like protruding blackened soralia, bears a deceptive resemblance to Arctic forms of *N. sulphureus*. Under the lens, however, it is immediately distinguished by the annular cracks of the smooth thallus branches, and this character, together with the reaction of the medulla, shows it to be within the form-circle of *N. acromelanus*.

No apothecia have been observed.

The distribution of this variety is of considerable interest from the phytogeographical standpoint (see map 2). The type-specimen in the British Museum Herbarium, together with a number of others all strictly conformable in character, was collected in Tasmania, summit of Table Mountain, by Robert Brown, 1802–5, and another, in Herb. Ch. Babington, is from Tasmania, Arthur's Lakes, coll. Gunn. Somewhat aberrant on account of its large size (6 cm.), but otherwise with all the characters of this variety, is a specimen preserved at Kew, from Chatham Island, coll. Travers. A small plant from Peru: Azangaro, leg. Lechler, 1854, forming part of a mixed collection of Lechler's 'Plantae peruvianae' in the British Museum Herbarium, is undoubtedly referable to this variety. Further, on examining the specimens recorded by Wainio, Rés. Voy. S.Y. Belgica, Lichens, p. 11 (1903), as '*Usnea sulphurea* var. *sorediifera*', I was surprised to find that they also belong here. They are slightly more robust than the other specimens, but show complete agreement in all important characters. These specimens were collected off the west coast of Graham Land, on Brabant Island in the Gerlache Channel, 'sur un rocher isolé au milieu d'un glacier, à 300 m. d'altitude au-dessus du niveau de la mer'. Probably this variety will eventually be found to occur all along the Andean chain between Peru and southern Chile, and search should be made for it also in New Zealand.



Var. *INACTIVUS* *M. Lamb*, var. nov.

*Diagn.*—Defectione acidi Depsidonici dignotus, medulla hanc ob rem KHO—, Pd—; ceterum ut in forma typica.

*Icon.*—Pl. 7, fig. 14 (part of the type-material; nomenclatural type on the left).

Apart from the absence of medullary reactions the only difference shown is a slight reduction in the size of the soralia.

Two specimens from Tasmania are present in the British Museum Herbarium: Mount Wellington, coll. W. Campbell, ex herb. Stirton (the type-specimen), and summit of Table Mountain, coll. Robert Brown, 1802–5 (intermixed with var. *decipiens*). In addition to these, a specimen from S. Patagonia, exact locality unspecified, coll. Prichard, 1900–1, although differing from the Tasmanian specimens in having its ultimate branches strongly blackened, appears to belong here.

Forma *PICATUS* *M. Lamb*, f. nov.

*Diagn.*—Rami thalli eximie late nigrati, quasi picati, circum basin tantum sulphurei.

*Icon.*—Pl. 9, fig. 21 (part of type-material; nomenclatural type on the left).

The thallus of this form presents habitually a very striking contrast to that of its parent variety, being subdecumbent and closely appressed to the rock. On account of the widespread blackening of the branches the numerous annular cracks in the cortex do not show up distinctly; where they occur in the yellow basal parts of the branches they are characteristically edged with black. Soralia are abundant, more or less blackened, varying from eroded to slightly convex.

Antarctic regions: South Victoria Land, Cape Adare or Sastrugi, collected by the British Antarctic Expedition, *Terra Nova*, 1910.

This, with the f. *scabridulus*, is an interesting southern extension in the range of this species, comparable to that afforded in *N. ciliatus* by the var. *subpolaris*.

The record 'Cape Sastrugi, Evancine New', given by Motyka (in Lich. Gen. Usn. Stud. Monogr. I, p. 24; 1936) for *N. antarcticus* refers partly to this specimen and partly to those of *N. ciliatus* var. *subpolaris*, all in the British Museum Herbarium; the locality should read: 'Cape Sastrugi, Evans Cove'.

Forma *SCABRIDULUS* *M. Lamb*, f. nov.

*Diagn.*—Thallus 3–4 cm. altus, pro maxima parte impure sulphureus, ramis terminalibus irregulariter nigratis; superficies ramorum sub lente leviter scabridula, papillis minutissimis nigratis superstrata.

*Icon.*—Pl. 5, fig. 6 (portion of thallus of type-specimen, four times natural size).

The branching of the thallus is irregular, and the annular cracks characteristic of the species only sparingly present. The minute rounded blackened papillae (less than 0.05 mm. diam.) scattered over the thallus branches are clearly distinguishable only with the aid of a  $\times 10$  lens; to the naked eye only a slight sooty shading of the thallus branches is apparent. Soredia are whitish, small, and poorly developed, but constantly present on the finer branches. The habitual resemblance of this plant to the type is slight, owing to the thick irregular branches and poorly developed soredia, but the occasional occurrence of black-edged annulations and the smooth 'waxy' appearance of the thallus surface between the papillae show it to belong to this species. On microscopic examination the minute black verruculae were seen to be elevations of the cortex coated with an outer layer of blue-green cells, and have no connexion with pycnidia.

The single specimen in the British Museum Herbarium is unfortunately without record of locality except for the word 'Antarctic', but it would seem probable that it was collected in the Ross Sea area.

*Stirps N. aurantiaco-atri (spp. 7-11).*

7. *N. AURANTIACO-ATER* (Jacq. emend. Mot.) *M. Lamb*, comb. nov.

*Synon.*—*Lichen aurantiaco-ater* Jacquin, Miscell. Austriac., II, p. 369 (1781). *Usnea fasciata* Torrey in Silliman's Amer. Journ. Sci. & Arts, VI, p. 106 (1823). *Usnea aurantiacoatra* Bory apud Dumont-D'Urville in Mém. Soc. Linn. Paris, IV, p. 596 (1826) (dubia). *Neuropogon antennarius* Nees & Flotow in Linnæa, IX, p. 497 (1835), fide Motyka, Lich. Gen. Usn. Stud. Monogr. I, p. 28 (1936). *Usnea melaxantha* var.  $\alpha$  *Acharii* Hook. fil. & Ch. Babington, Bot. Antarct. Voyage *Erebus* and *Terror*, I, Flora Antarctica, pt. 2, p. 520 (1847)\*. *Usnea melaxantha* var.  $\beta$  *Jacquinii* Hook. fil. & Ch. Babington, loc. cit.\* (dubia). *Usnea melaxantha* var.  $\gamma$  *fasciata* Hook. fil. & Ch. Babington, loc. cit.\* *Usnea melaxantha* var.  $\delta$  *sphacelata* Hook. fil. & Ch. Babington, loc. cit. (Non *Usnea sphacelata* R. Br.!) (dubia). *Usnea antennaria* Massalongo, Memor. Lichenogr. p. 73 (1853). *Neuropogon sulphureus* Hellbom in Bihang till Kgl. Svensk. Vet.-Akad. Handl. XXI, Afd. 3, no. 13, p. 21 (1896), pro parte\*. *Usnea sulphurea* var. *normalis* Wainio, Rés. Voy. S.Y. Belgica, Lichens, p. 11 (1903), pro parte. *Usnea trachycarpa* var. *eciliata* Räsänen in Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, II, no. 1, p. 10 (1932), fide Motyka, Lich. Gen. Usn. Stud. Monogr. I, p. 28 (1936). *Usnea Taylora* var. *subciliata* Räsänen in loc. cit. (fide Motyka, loc. cit.) (see p. 231). *Usnea Taylora* var. *Kranckii* Räsänen in loc. cit., sec. descript.

*Icon.*—Pl. 10, fig. 23 (the type-specimen of '*Usnea fasciata*' Torrey). Further:—Jacquin, Miscell. Austriac., II, Tab. xi, fig. 2 (1781). Torrey in

\* Applicable only to the whole form-circle of *N. aurantiaco-ater*, or possibly to *N. melaxanthus*.

Silliman's Amer. Journ. Sci. & Arts, VI, Tab. IX (1823) (*minime bona*). Massalongo, Memor. Lichenogr. Tab. 12, fig. 80 (1853).—Tuckerman, Lichens, in United States Exploring Exped. 1838–42, under the command of Chas. Wilkes, XVII, tab. i, figs. 1–6 (1862)\*. Lindsay in Trans. Linn. Soc. Lond. XXV, tab. lxi, fig. 28 (1866)\*. Reinke in Pringsheim, Jahrbüch. f. wiss. Bot. XXVIII, p. 397, fig. 117, i–ii (1895)\*. Arcangeli in Atti Soc. Toscana Sci. Nat. Memor. XX, tab. vi (1904)\*.

The type-specimen of Jacquin's '*Lichen aurantiaco-ater*' has unfortunately been lost. Jacquin's Herbarium was purchased by Sir Jos. Banks and incorporated in the Banksian collection, now part of the British Museum Herbarium; but the lichen types do not appear to have been included with it. Acharius, in his original description of '*Usnea melaxantha*', lists Jacquin's name as a doubtful synonym, and some subsequent authors, such as Tuckerman (op. cit. p. 125) and Du Rietz (Svensk Bot. Tidskr. XX, p. 91, 1926), have not hesitated to regard the two species as identical. Others have rejected Jacquin's epithet as being dubious, and employed in preference Acharius's '*melaxantha*'. Up till comparatively recent times the latter specific epithet has been used indiscriminately for almost every species of *Neuropogon* from both hemispheres.

Jacquin states (op. cit. p. 368) that '*Lichen aurantiaco-ater*' was one of three lichens collected by Commerson, the locality given for the other two being the Magellan Strait. Although no station is mentioned for '*L. aurantiaco-ater*', it is almost certain that it also was collected in or near the same region. The figure, although crude, represents without doubt a plant of the '*melaxantha*'-type.

Motyka (in Lich. Gen. Usn. Stud. Monogr. 1, p. 27; 1936) believes that '*Lichen aurantiaco-ater*' is sufficiently defined by the original description and figure to allow it to be specifically distinguished from '*Usnea melaxantha*' Ach. on the basis of the superficial texture of the thallus, its anatomical structure, and its chemical reaction. Distinction under the first two heads I have found after examination of copious material to be impossible; every conceivable intergrade occurs, these characters being conditioned by age and environment. The chemical reaction of '*Usnea aurantiaco-atera*' is assumed as: '*K aut omnino non reagens aut tardissime flavescens et dein fusco-rubescens*'. This reaction is characteristic of Protocetraric or Fumar-protocetraric acid, and such plants if tested with Pd will give a yellow then miniate red coloration of the medulla. From consideration of the distribution of the chemically distinct species of the '*melaxantha*'-type, it appears that Motyka has probably construed the chemical nature of the lost type of Jacquin precisely. Within this group, plants containing Protocetraric or Fumar-protocetraric acid appear to dominate in Tierra del Fuego, from the Magellan Strait to Staten Island. *N. melaxanthus*, which contains Salazic acid and/or Salazic acid  $\alpha$ -methyl-ether

\* Applicable only to the whole form-circle of *N. aurantiaco-ater*, or possibly to *N. melaxanthus*.

(or Norstictic acid), and hence gives a yellow then blood-red reaction of the medulla with potash, has its centre of distribution in the Falkland Islands, to which it is not, however, endemic, for I have seen specimens from the Chilean Andes, Magellan Straits, Cape Horn, and Staten Island (see p. 228). Outside the Falkland Islands, however, it appears to be rare, its place being taken by the species containing Protocetraric or Fumar-protocetraric acid.

These facts favour Motyka's view concerning the potash reaction in '*Lichen aurantiaco-ater*', and the species-description is here considered as emended by him as regards the chemical constitution.

I was fortunate in being able to obtain from the New York Botanical Garden the type-specimen of Torrey's '*Usnea fasciata*' from the South Shetlands. This specimen, the exact nature of which had remained doubtful ever since it was first described in 1823, is shown in Pl. 10, fig. 23; it is the typical *N. aurantiaco-ater* as delimited here, the medullary reaction being: KHO+ yellow-brown, Pd+ yellow then miniate red. Motyka, in Lich. Gen. Usn. Stud. Monogr. I, p. 31 (1936), although he had not seen the type-specimen nor the original description, construed the identity of this species with remarkable accuracy; only in his description too much value is attributed to slight differences in habit and a black 'fasciation' observed by him in some specimens and resulting from the erosion of the cortex by climatic influences. The brown corneous nature of the axis, also considered by him to be diagnostic, is not a good systematic criterion within this group; I have found the colour and consistency of the axis to show all grades of variation between white and matt on the cut surface to the condition described by Motyka. Apparently it depends on the age of the specimen when gathered. In the type-specimen of '*Usnea fasciata*' the axis is white, not corneous. Motyka describes the potash reaction as negative, so that his description actually refers either to f. *normalis* (Wain.) or to f. *egentissimus* M. Lamb. In the exsiccata Zahlbruckner, Lich. rar. exsicc. no. 37, quoted by Motyka, the reactions of the medulla in the Berlin specimen are: KHO—, Pd+ yellow then miniate red, hence showing it to be f. *normalis*. '*Usnea melaxantha* var. *subciliata*' Zahlbr., listed as a synonym by Motyka, belongs to a distinct species (see p. 231). Räsänen's '*Usnea Taylori* var. *Kranckii*', of which I have not seen the original, is considered by Motyka to belong also to '*U. fasciata*' in his delimitation: from the reaction mentioned by Räsänen it is apparently referable to the typical form of *N. aurantiaco-ater*.

There is no sanction in the International Rules of Botanical Nomenclature for the omission of the hyphen in Jacquin's epithet *aurantiaco-ater*.

I have seen specimens of the typical form from Cape Horn, Staten Island, Falkland Islands (one specimen in Herb. Kew, coll. Robinson), the South Orkneys, the South Shetlands, and Galindez Island in the Argentine group. It is certainly rare in the Falklands, and in the three latter eu-Antarctic stations appears to decline in abundance in favour of the acid-poorer forms *normalis* and *egentissimus*. Nos. 249 pro parte and 197 pro parte of the Belgian Antarctic Expedition, mentioned by Wainio, loc. cit., under '*Usnea sulphurea* var.

*normalis* ', also belong here ; they were collected at Brabant Island and Cape Anna Osterrieth respectively. Some at least of Hue's material from Graham Land (Booth-Wandel and Hovgaard Islands) mentioned in Expéd. Antarct. Franç. (1903-5), p. 3 (1908) as '*Usnea melaxantha* ', is shown by the description to be also the typical form of *N. aurantiaco-ater*. The same probably applies to some of the material from the South Shetlands cited by Hue in Deux. Expéd. Antarct. Franç. (1908-10), p. 24 (1915).

*Key to the forms of N. aurantiaco-ater.*

Thallus branches closely and finely, although irregularly, fibrillose ; medulla KHO+ brownish, Pd+ yellow then miniate red ...	<i>nigropallidus</i> .
Thallus branches with few or no capillary fibrillae. Medulla KHO+ brownish, Pd+ yellow then miniate red ....	Forma typica speciei.
Medulla KHO-, Pd+ or -.	
Medulla Pd+ yellow then miniate red .....	<i>normalis</i> .
Medulla Pd- .....	<i>egentissimus</i> .

Forma *NIGROPALLIDUS* (Ceng. Samb.) *M. Lamb*, comb. nov.

*Synon.*—*Usnea melaxantha* var. *nigropallida* Cengia Sambo in Bull. Soc. Bot. Ital. nos. 4-5, p. 91 (1926).

*Icon.*—Pl. 8, fig. 18 (the type-specimen).

The type-specimen from Tierra del Fuego is chemically indistinguishable from the typical form, but differs in the strong development of almost capillary fibrillae on the thallus branches. The fibrillae do not, however, tend to be of uniform length, as in *N. strigulosus*. The colour is that normally found in comparatively recently gathered specimens.—Sterile.

To this form I have been able to refer several specimens of *N. aurantiaco-ater* collected off the west coast of Graham Land, Galindez Island, by the British Graham Land Expedition (no. 1340, pro parte).

Forma *NORMALIS* (Wain.) *M. Lamb*, comb. nov.

*Synon.*—*Usnea sulphurea* var. *normalis* Wainio, Rés. Voy. S.Y. *Belgica*, Lichens, p. 11 (1903), pro parte.

*Icon.*—Pl. 9, fig. 20 (specimen from the Argentine group, Galindez Island, coll. British Graham Land Expedition, 1934-7).

*Exsicc.*—Zahlbruckner, Lich. rar. exsicc., no. 37.

Wainio did not designate any particular specimen as the type of his '*var. normalis* ', and five specimens are present in his herbarium bearing this name ; of these, two give a brownish reaction of the medulla with KHO, and are hence referable to the typical form of *N. aurantiaco-ater*, while the others give no perceptible potash reaction, but show a miniate red coloration of the medulla with Pd. In his original description, Wainio writes : '*KHO non reagens* ', and hence the latter plants must be regarded as forming the type-material of this variety.

It is merely a stage in the dwindling gradation of the lichen acid content, possibly due to environmental conditions. None of the material under this name in Herb. Vainio is referable to '*Usnea melaxantha* var. *subciliata* f. *strigulosa*' Zahlbr., as claimed by Motyka (Lich. Gen. Usn. Stud. Monogr. 1, p. 30; 1936).

First recorded from Cape Renard, between the Bismarck and Gerlache Straits; good fruiting material of this form has also been brought back by the *Discovery* and British Graham Land Expeditions from the South Shetlands and the Argentine group. It occurs also in sub-Antarctic S. America, as Zahlbruckner's exsiccata shows (Patagonia, coll. Neumann).

Forma EGENTISSIMUS *M. Lamb*, f. nov.

*Diagn.*—Thallo acidum Protocetraricum aut Fumar-protocetraricum plane deficiens, quare medulla KHO—, Pd—; ceterum ut in typo.

This form, differing from the foregoing only in the complete absence of any medullary reaction with Pd as well as with KHO, might have been regarded as perhaps a variety of *N. melaxanthus*, but for the obviously intermediate position of f. *normalis*. In the British Museum Herbarium material is present from the South Shetlands and Galindez Island in the Argentine group, collected by the British Graham Land Expedition (no. 1340, pro parte). The latter specimen is the type of this form. No. 208, pro parte, of the Belgian Expedition (Herb. Vainio no. 345), from Auguste Island in the Gerlache Channel, referred to by Wainio, loc. cit., as '*Usnea sulphurea* var. *normalis*', proved upon examination to belong here also. It occurs also in sub-Antarctic S. America; two specimens are present in the Kew Herbarium from the following localities: S. part of Tierra del Fuego, leg. C. Darwin, 1833, and S. Chile, Antuca, leg. Reynolds (no. 141).

*F. egentissimus* inhabits the same stations as the type and f. *normalis*, and was collected with these under one number by the British Graham Land Expedition. Hence it appears unlikely to be a non-systematic variant induced by climatic conditions.—Apothecia are usually abundantly present. In a specimen from the South Shetlands, coll. Bennett, 1925, I found pycnidial fulera of the endobasidial type with pycnoconidia 10–12 by 1.5  $\mu$ .

8. *N. MELAXANTHUS* (*Ach.*) *Nylander* in Mém. Soc. Imp. Sci. Nat. Cherbourg, III, p. 170 (1855)\*.

*Synon.*—*Usnea melaxantha* Acharius, Method. Lich. p. 307 (1803). *Cornicularia flavicans* Persoon apud Gaudich. Voyage autour du Monde, Bot. p. 210

\* The material upon which Nylander actually based this combination was *N. sulphureus*, but at the Sixth International Botanical Congress at Amsterdam, 1935, it was decided that in the case of an author who makes a new combination, but applies it erroneously to a different plant, the combination should nevertheless be attributed to him, and not to the author who subsequently applies it to the correct plant.

(1826), fide Motyka, Lich. Gen. Usn. Stud. Monogr. I, p. 33 (1936). *Parmelia melaxantha* Spreng. Syst. Veget. iv, pars 1, p. 277 (1827), pro parte. *Usnea sulphurea* var. *normalis* f. *activa* Zahlbruckner in Kgl. Svensk. Vet.-Akad. Handl. LVII, no. 6, p. 44 (1917). *Usnea sulphurea* f. *activa* Zahlbruckner, Cat. Lich. Univ. VI, p. 603 (1930).

*Icon.*—Pl. 11, fig. 28 (the type-specimen in Herb. Acharius); fig. 25 (aged specimens of abnormal appearance). Further: Lindsay in Trans. Roy. Soc. Edinburgh, XXII, tab. iv, figs. 9–11 (1859). Maheu & Gillet in Bull. Soc. Bot. France, LXX, p. 488, figs. 1–4 (1923).

The type-specimen in Acharius's Herbarium at Helsinki consists of two plants, one, the larger, from the W. Falklands, Port Egmont, and the other from 'Staaten Land'. I follow Motyka's example in regarding the former as the nomenclatural type; actually both specimens are slight habitual variants of the same species, and their medullary reactions are the same, i.e. KHO+ intense yellow quickly changing to blood-red, Pd+ deep golden yellow with a slight orange tinge. Motyka's excellent description in Lich. Gen. Usn. Stud. Monogr. I, p. 33 (1936), together with the illustration given here, makes a recapitulation of the diagnostic features unnecessary.

This species is very well represented in the British Museum Herbarium and at Kew, and it was hence possible to make observations on the constancy and importance of certain characters which have been used for its differentiation. The results of these observations may be summarized as follows:—

(1) The number and size of the branches is liable to extreme variation; the plants shown in Pl. 11, fig. 25, might well be classified as an independent variety or even species, if all intermediate gradations were not known to occur. The specimens shown are aged individuals, in which the lateral branches and fibrillae have been shed. Observations on the verruculae and rugosities so characteristic of thalli of this species and of *N. aurantiaco-ater* show that the papillae are connected with the formation of lateral fibrillae. Some are incipient fibrillae, which do not emerge beyond the verrucular condition, while others are the healed-over stumps of fibrillae which have been shed or removed by environmental agencies. In older individuals and parts of the thallus plications develop between the verruculae, giving rise to a rugose condition; in aged plants, such as that on the right in Pl. 11, fig. 25, foveolations develop between the plicate ridges.

(2) The pinkish colour of the medulla seen in some specimens, and considered by Motyka as characteristic of this species, is a secondary alteration due to preservation in the herbarium. All the specimens collected by J. D. Hooker on the Antarctic Expedition of 1839–43 have a pronounced pink tinge in the medulla, as have also many others collected during the past century. More recently gathered specimens have an entirely white medulla. The colour-change in the herbarium goes hand in hand with a progressive darkening of the outside of the thallus; old herbarium material is commonly of a dark reddish-brown colour. Hooker and Churchill Babington, in Bot. Antarct. Voyage *Erebus* and

*Terror*, I, Flora Antarctica, pt. ii, p. 520 (1847), have remarked that this darkening of the thallus may be hastened by immersion in warm water. In my own experience cold water will also produce this effect. Apparently the change is due to alteration in the chemical constitution of the characteristic substances formed in cortex and medulla; in the case of the latter, however, it is without effect on the reactions produced with KHO and Pd. The pink coloration of the medulla is not met with only in plants containing Salazic acid; I have observed the same phenomenon in old collections of *N. aurantiaco-ater*, although in a lesser degree of intensity.

(3) As mentioned in connexion with *N. aurantiaco-ater*, the colour and consistency of the central axis is subject to fluctuation, apparently with the age of the individual, and hence cannot be used as a basis for specific segregation. Possibly it is more constant in some other species, such as *N. strigosus*. If this proves to be the case, on examination of copious material, it will provide an extremely useful taxonomic criterion, as it does not seem to be affected by prolonged preservation in the herbarium.

(4) The variation in the Pd reactions shown by different individuals was investigated. Although all specimens of this species give the same reaction of the medulla with KHO, namely, intense yellow quickly going over into deep blood-red, the Pd reaction is less constant, ranging from an orange-red through inseparable gradations to pure golden-yellow. As mentioned on p. 201, the blood-red reaction with potash is characteristic of three distinct lichen acids: Salazic acid, Salazic acid  $\alpha$ -methyl-ether, and Norstictic acid. Asahina has shown that the former compound can be distinguished from the other two by the form of the crystals of the Potassium salt under the microscope—sheaf-like aggregations of Potassium salazinate, and loosely crossed or isolated acicular crystals of Potassium  $\alpha$ -methyl-ether salazinate or Potassium norstictate respectively. Also it has been shown by Asahina that Salazic acid in the pure state produces an orange-red compound with Pd, while the other two lichen acids are characterized by a yellow to ochre-yellow coloration with this reagent. In the foreword to this paper I have shown that in certain circumstances the Salazic acid content of a lichen fails to produce characteristic sheaf-like bundles with potash, forming only short broadly rectangular or square tabular crystals. All the material of *N. melazanthus* in the British Museum Herbarium was tested microscopically with potash and macroscopically with Pd in order to ascertain what correlation, if any, obtained between the crystals of the Potassium salt, the nature of the reaction produced with Pd, the age of the plant, and the locality from which it was collected. The results demonstrated that no such correlation exists; certain specimens showing well-defined sheaf-like crystals of Potassium salazinate gave a yellow to ochre-yellow reaction with Pd, while others furnishing an orange or orange-red coloration with the latter reagent produced with potash crystals more referable to Potassium  $\alpha$ -methyl-ether salazinate or Potassium norstictate than to Potassium salazinate. In a large number of cases it was



impossible to refer with certainty the crystals observed to either of the alternative forms. The age of the specimens and their geographical distribution were without influence on the medullary reactions with KHO and Pd. It hence seems most probable that this species is capable of producing either Salazic acid or Salazic acid  $\alpha$ -methyl-ether (or Norstictic acid), and that in the majority of cases both are formed in varying quantities in the same thallus; this would account for the variation observed in the coloration produced with Pd. Asahina has shown that different Depsidone substances frequently occur side by side in the same lichen thallus, e.g. Salazic acid  $\alpha$ -methyl-ether and Salazic acid  $\beta$ -methyl-ether in *Usnea articulata* var. *asperula* Muell. Arg. It is hoped to settle the question as regards *N. melaxanthus* by macrochemical analysis at a later date.

*N. melaxanthus* is undoubtedly common in both the East and the West Falklands, as testified by collectors' notes and the abundance of material in the herbaria. The following records, based on specimens in the British Museum Herbarium and at Kew, may be added to the list given by Motyka: East Falklands, exact locality not stated, leg. R. O. Cunningham, 1869; 'Falkland Island', exact locality and collector not stated, ex herb. E. Forster; East and West Falklands, exact locality not stated, leg. Vallentin, 'common'; Falkland Islands, exact locality not stated, leg. J. D. Hooker, 1844; East Falklands, Mount Lowe, alt. about 600–700 feet, leg. F. J. Smith, 1937; in the Kew Herbarium: Falkland Islands, exact locality not stated, leg. Capt. Black; Falkland Islands, exact locality not stated, leg. Wright. Outside the Falkland Islands, *N. melaxanthus* is known to occur at Cape Horn, Hermite Island, leg. J. D. Hooker, Antarctic Expedition 1839–43 (in British Museum Herbarium), Staten Island (specimen in the Acharian Herbarium at Helsinki), Magellan Strait, leg. Whinnie (in Herb. Kew), and 'Andes of Chili', exact locality and collector unspecified (in Herb. Kew). The form *spadicea* has been recorded by Motyka also from Staten Island, in Lich. Gen. Usn. Stud. Monogr. 1, p. 35 (1936). Motyka further lists a specimen of *N. melaxanthus* from South Georgia, leg. Bergström, 1921, and enumerates doubtful records from the South Shetlands, Chile, Patagonia, and New Zealand. A surprising record is that of Maheu and Gillet (in Bull. Soc. Bot. France, LXX, p. 487; 1923), from England, 'Sanasend près de Norwich'; I have not been able to see the specimen, but it is undoubtedly referable to this species. In my opinion it is incredible that it ever grew in England, and the 'record' almost certainly has its origin in some confusion of material; also I have not been able to trace any locality 'Sanasend' either in Norfolk or Suffolk.

Forma SPADICEUS (*Zahlbr.*) *M. Lamb*, comb. nov.

*Synon.*—*Usnea sulphurea* var. *spadicea* Zahlbruckner in Kgl. Svensk. Vet.-Akad. Handl. LVII, no. 6, p. 45 (1917). *Usnea melaxantha* var. *spadicea* Motyka, Lich. Gen. Usn. Stud. Monogr. 1, p. 35 (1936).

*Icon.*—Pl. 9, fig. 19 (the type-specimen).

Distinguished from the typical form only by the date-brown (not black) colour of the annulations on the branches. Close investigation of the fertile type-specimen from the West Falklands, Mount Adams, revealed one sterile branch with completely black annulations, springing from the same basal disk ; its markings conserve their character throughout, no intergrades being present. It seems as if one is here dealing with two distinct plants whose basal disks have become coalescent. In any case, both are referable to *N. melaxanthus*, giving the same characteristic reactions with potash and Pd.

Known at present only from two localities in the Falkland Islands and from Staten Island, according to Motyka.

9. *N. AURANTIACUS* (Mot.) M. Lamb, comb. nov.

*Synon.*—*Usnea aurantiaca* Motyka, Lich. Gen. Usn. Stud. Monogr. I, p. 29 (1936).

*Exsicc.*—Zahlbruckner, Lich. rar. exsicc. no. 20 (non vidi).

Unfortunately I have been unable to see the exsiccata upon which Motyka has based this species, and have included it in the key on p. 207 from the description alone. The yellow then blood-red reaction with potash may indicate an affinity either with *N. melaxanthus* or *N. trachycarpus* f. *trachycarpoides*. The size and habit of the plant as described by Motyka appears to approach that of the latter, but the very verruculose thallus branches are unlike those of *N. trachycarpus*, and the eciliate apothecia with their black disks show that *N. aurantiacus* is better included in the vicinity of *N. melaxanthus*. Motyka records it from the Falklands, the Magellan Strait, and Tierra del Fuego. I have not yet come across any material recognizable with certainty from the description as belonging to this species.

10. *N. STRIGULOSUS* (Zahlbr.) M. Lamb, comb. nov.

*Synon.*—*Usnea melaxantha* var. *subciliata* f. *strigulosa* Zahlbruckner in Ann. Mycol. I, p. 360 (1903). *Usnea melaxantha* f. *strigulosa* Howe jun. in Bryologist, XVIII, p. 61 (1915). *Usnea sulphurea* var. *subciliata* f. *strigulosa* Zahlbruckner, Cat. Lich. Univ. VI, p. 603 (1930). *Usnea strigulosa* Motyka, Lich. Gen. Usn. Stud. Monogr. I, p. 30 (1936).

*Icon.*—Pl. 10, fig. 22 (the type-specimen).

The copious development of lateral fibrillae is reminiscent of that seen in *N. trachycarpus* ; the true affinity is, however, not with that species, but with *N. aurantiaco-ater*. The fibrillae are formed in the same way as those of the latter species, arising from the verruculae on the thallus branches and leaving when shed short stumps which heal over and form in their turn rounded papillate excrescences.

In the type-specimen the medullary reactions are : KHO— or + faintly yellowish ; Pd+ yellow than miniate red. Protocetraric or Fumar-protocetraric acid is thus indicated. Motyka (Lich. Gen. Usn. Stud. Monogr. I, p. 30, 1936),

records the potash reaction as 'vulgo sat distincte rubescens'; probably in some forms sufficient of the lichen acid is present to produce this coloration. As there appears to be some uncertainty in the delimitation of this species, the following morphological description is appended; it refers solely to the type-specimen from Patagonia, coll. Neumann, in the Herbarium of the Naturhistorisches Hofmuseum in Vienna:—

Thallus up to 8 (–10) cm. high, commencing to ramify almost from the base, the branching, however, not copious. Lateral fibrillae abundant down to within 2 cm. of the base, simple or branched, capillary or subcapillary, either completely yellow or black-annulate, acuminate; terminal ramifications of the main branches not fibrillose, but rather coarse, elongated and straggling, acuminate. Colour of thallus a light yellow, in some places with a slight olivaceous greenish tinge; surface matt. The branches become relatively attenuated before the black annulation sets in; towards their ends they become entirely black. From the base upwards the thallus is for the first 1.5–2.5 cm. almost smooth, slightly verruculose or finely plicate; thereafter (between the lateral fibrillae) distinctly verruculose, the verruculae scattered or approximated; in some places a certain amount of plication and scrobiculation is also present. Medulla white, compact; central axis thick, occupying  $\frac{2}{3}$  or more of the diameter of the branch, dull yellowish brown, of corneous texture.

Apothecia numerous, laterally situated near or at some distance from the ends of the branches, 0.2–0.9 cm. diam., at first concave, ultimately becoming almost plane; excipulum verruculose or slightly plicate, in most apothecia furnished with a variable number (2–16 or more) of ciliate fibrillae up to 7 mm. in length. Disk dark brown-black to pitch-black, matt or subnitid, smooth or in older apothecia irregularly roughened, not pruinose. Hymenium 40–60  $\mu$  high; paraphyses concrete, blue-green towards their apices. Spores colourless, simple, ellipsoid, about 12 by 7–8  $\mu$ ; spore-wall about 0.7  $\mu$  thick.

In conformity with the International Rules of Botanical Nomenclature, the first specific epithet published within the form-circle of this species, namely, '*strigulosa*' (Zahlbr.) Mot., is adopted, although the taxonomic entity indicated by this name was originally published by Zahlbruckner as subordinate in rank to his '*var. subciliata*', here considered as a form.

'*Usnea aurantiacoatra*' and '*Usnea Taylora* var. *subspadicea*' recorded by Räsänen in Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, II, no. 1, pp. 9 & 11 (1932), are considered by Motyka (loc. cit.) to be referable to this species. Räsänen's mention of a rusty reddish reaction with potash in the former indicates the presence of Protocetraric or Fumar-protocetraric acid in some abundance.

According to Motyka, this species has a wide distribution in sub-Antarctic S. America, South Georgia, and Graham Land with its adjacent islands (including the South Orkneys and Shetlands). In my opinion many of the eu-Antarctic records are to be looked upon with mistrust; young infertile plants of

*N. aurantiaco-ater* may often bear a certain resemblance to this species, as in the case of var. *nigropallidus* (p. 224). In the abundant material from the Graham Land region collected by the *Discovery* and British Graham Land Expeditions no plants referable to *N. strigosus* were present. A specimen in the British Museum herbarium from 'N. S. Shetland', exact locality and collector not stated, ex herb. Churchill Babington, may belong to the following form, but is not determinable with certainty on account of the absence of apothecia.

Forma SUBCILIATUS (*Zahlbr.*) *M. Lamb*, comb. nov.

*Synon.*—*Usnea melaxantha* var. *subciliata* Zahlbruckner in Ann. Mycol., I, p. 360 (1903). *Usnea sulphurea* var. *subciliata* Zahlbruckner, Cat. Lich. Univ. VI, p. 603 (1930).

*Icon.*—Pl. 10, fig. 24 (the type-specimen).

This form has been considered by Motyka (in Lich. Gen. Usn. Stud. Monogr. I, p. 31; 1936) to be identical with Torrey's '*Usnea fasciata*'. Examination of the type-specimen from Patagonia, coll. Neumann, however, has shown it to be a non-fibrillose form of *N. strigosus*. In the type-specimen of this form the apothecial margins are more densely ciliate than in the typical species, the cilia being also longer (up to 1.3 cm.); the reactions with KHO and Pd, anatomical structure, etc., are exactly as in the typical form.

I have not seen the specimen of '*Usnea Taylora* var. *subciliata*' Räsänen, in Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, II, no. 1, p. 11 (1932), but from the description it might seem more appropriate to include it here than with *N. aurantiaco-ater*, where it has been placed by Motyka (op. cit. p. 28).

Since in Motyka's list f. *subciliatus* has been included within a separate and distinct species, it is impossible to determine which of the localities there given actually refer to this form. With the exception of the doubtful specimen from the South Shetlands mentioned above, I have seen no material other than the type-specimen.

#### 11. *N. SUBSTRIGULOSUS* *M. Lamb*, sp. nov.

*Diagn.*—Thallus robustus, major (usque ad 8.5 cm. altus), erectus vel nonnihil expansus, parte basali substrato affixus, modice ramosus; rami 1.3–2.3 mm. crassi, infra interdum angustiores, teretes vel leviter angulato-compressi, fibrillis lateralibus brevibus numerosissimis muniti; aut leves vel leviter plicati aut passim quoque verruculosi, superficie opaca. Color thalli nunc pallide rufo-fuscescens, ramulis terminalibus fibrillisque lateralibus pallidior, ochraceo-flavescens, ibique tantum irregulariter annulatim nigratus. Rimæ nigratae atque soredia desunt.—Cortex 100–200  $\mu$  crassus, flavidus, e hyphis conglutinatis pachydermaticis anastomosantibus parum distinctis. Medulla

crebra, alba vel paulo roseola, gonidia irregulariter disposita continens. Axis  $1/3-5/12$  diametri ramorum, solidus, haud laceratus, plus minusve vitreo-pellucidus, pallide flavidus vel fuscescens.

Apothecia passim numerosa, lateralia, ramorum apices versus sita, majora (usque ad 1.5 cm. diam.), plus minusve concava, rotundata vel irregulariter incisa; excipulum plicatum verruculosum, subtus margineque fibrillis munitum valde numerosis, simplicibus ramosisve, ochraceo-flavescentibus et irregulariter nigro-annulatis. Discus rufo-fuscescens, haud pruinosis.—Hymenium 50–60  $\mu$  altum, pallide flavidum, epithecio granuloso cum hypothecio quoque leviter flavescenti. Sporae 8-nae, simplices, ellipsoideae, incolores, longit. 12, crassit. 6  $\mu$ , pariete usque ad 1  $\mu$  crasso.

Medulla KHO+ flava deinque sanguinea (crystallis rubris praecipitatis), Pd+ flava vel aurantiaco-flava.

[Pycnidia non visa.]

*Loc.*—Falkland Islands, exact locality and name of collector not stated, in the Kew Herbarium (type-specimen); another specimen from the Falklands, also without exact locality, collected by J. D. Hooker, is present in the same herbarium. In the British Museum a small specimen from Cape Horn, ex. herb. Churchill Babington, also probably collected by Hooker, belongs here, agreeing in all respects with the Falkland plants.

*Icon.*—Pl. 7, fig. 15 (the type-specimen).

This plant might at first sight be regarded as a gigantic form of *N. trachycarpus* f. *trachycarpoides*, which rarely reaches a height of 6 cm. There is, however, besides the distinction of size, a marked difference in the habit of the two species, difficult to define in words, but sufficiently obvious from the illustrations. The character of the excipular cilia also affords a good distinction, these being in *N. substrigosus* somewhat coarse (0.3–0.5 mm. thick) and variegated with black and yellow in about equal proportions, while in *N. trachycarpus* they are finer, subcapillary (0.1–0.3 mm. in thickness), and almost entirely black. The thalline characters of the new species determine its position in the *aurantiaco-ater* section of the genus *Neuropogon*.

On the addition of KHO+K<sub>2</sub>CO<sub>3</sub> solution to a section of the thallus under the microscope, acicular crystals characteristic of Potassium  $\alpha$ -methyl-ether salazinate or Potassium norstictate were formed.

*Stirps* *N. trachycarpi* (sp. 12).

12. *N. TRACHYCARPUS* *Stirton* in Scottish Naturalist, vi, p. 105 (1881).

*Synon.*—*Usnea melaxantha* var. *angulosa* Muell. Arg., in Flora, LXXI, p. 528 (1888), fide Motyka, Lich. Gen. Usn. Stud. Monogr., i, p. 37 (1936). *Usnea trachycarpa* Müll.-Arg. in Nuov. Giorn. Bot. Ital. XXI, p. 37 (1889). *Usnea trachycarpa* var. *sublaevis* Müll.-Arg. in Hedwigia, XXXIV, p. 139 (1895), fide Motyka, loc. cit. *Usnea Hyypae* Räsänen in Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo, II, no. 1, p. 11 (1932), fide Motyka, loc. cit.

*Icon.*—Pl. 6, fig. 11 (the type-specimen in Herb. Stirton) ; Pl. 5, fig. 2 (specimen in the British Museum Herbarium from Kerguelen, coll. Eaton).

This small usually densely fibrillose species is easily recognized on account of its characteristic habit and ciliate apothecia with brownish flesh-coloured or buff disk.

As regards the chemical reactions, Stirton, in his original description, stated that the medulla in the type-specimen is KHO— ; I found it to be KHO— or + yellow then faintly reddish, Pd+ persistently yellow. Under the microscope no crystals are formed with alkali solution, but the nature of the macroscopic reactions indicates a very low concentration of one of the Depsidones of the Salazic acid group. Actually, as chemical study of the following form has shown, the compound present is Salazic acid.

The medulla, the lax nature of which is considered by Motyka to be characteristic of this species, is subject to considerable variation as regards thickness and texture. In some specimens of *N. trachycarpus* it is almost as loose as in *N. sulphureus*, but usually much less so, and in the type-specimen itself it is as compact as in other Southern Hemisphere species of the genus.

*N. trachycarpus* is frequently fertile.

Originally described from Kerguelen, where it appears to be common. It occurs also in sub-Antarctic S. America : Chile, Patagonia, and Fuegia.

Forma *TRACHYCARPOIDES* (Wain.) M. Lamb, comb. nov.

*Synon.*—*Usnea trachycarpa* var. *trachycarpoides* Wainio, Rés. Voy. S.Y. *Belgica*, Lichens, p. 12 (1903).

*Usnea Naumannii* Muell.-Arg. in Engl. Bot. Jahrb., iv, p. 54 (1883), fide Motyka, Lich. Gen. Usn. Stud. Monogr., 1, p. 38 (1936).

*Icon.*—Wainio, Rés. Voy. S.Y. *Belgica*, Lichens, pl. iii, figs. 20–22 ; pl. iv, fig. 31 (1903).

As Motyka points out, the only real difference between this form and the typical species lies in the intensity of the chemical reaction of the medulla ; in f. *trachycarpoides* it is ' K sat distincte rubescens ' (Motyka, loc. cit.). This difference is due to the greater quantity of Salazic acid present, and the addition of alkali solution under the microscope gives rise to crystals characteristic of the Potassium salt of this Depsidone compound. With Pd an orange coloration of the medulla is produced. As in the forms *normalis* and *egentissimus* of *N. aurantiaco-ater*, the systematic distinction rests only on a difference in the quantity of lichen acid present.

Motyka has overlooked the occurrence of this form in the Falkland Islands ; in the British Museum herbarium two specimens are present from the following localities : East Falklands, Port William Stanley, leg. Lechler (Lechler, Pl. ins. Maclov., no. 69 c) ; West Falklands, Cook Hill, leg. Vallentin. F. *trachycarpoides* is known to occur in sub-Antarctic S. America, but has not been found in Kerguelen.

*Stirps N. perpusilli (sp. 13).*13. *N. PERPUSILLUS M. Lamb, sp. nov.*

*Diagn.*—Thallus pusillus (1.8–2.3 cm.), erectus, parte basali substrato affixus; caulibus numerosis e basi excrecentibus, parce ramosis, infra modice incrassatis (0.3–0.9 mm.), apicem versus sensim attenuiscentibus, et ad apices subcornuto-acuminatis. Ramuli laterales fere desunt. Rami teretes, leves, opaci subnitidive, superficie haud verruculosi, passim tantum leviter foveolati; rimis et sorediis nullis. Color thalli nunc pro maxima parte stramineo-luteus vel rubricosus-fuscescens, ramorum apices versus nigro-variegatus, partibus extremis omnino nigratis.—Cortex 40–60  $\mu$  crassus, flavido-nubilatus, hyphis pachydermaticis anastomosantibus parum distinctis. Medulla crebra, alba, gonidia irregulariter disposita continens. Axis circ.  $\frac{1}{2}$  diametri ramorum, albidus, haud vitreo-pellucidus, nec laceratus nec excavatus.

Apothecia rara, ad ramos lateralia, minuta (0.5–0.8 mm. diam.), urceolata deinque plana, ad basin parum constricta; excipulum integrum, eciliatum, nigro-variegatum vel omnino nigrum. Discus niger, opacus, haud pruinosus.—Hymenium 50–70  $\mu$  altum, in parte superiore irregulariter aeruginosum, granulis subflavis onustum. Sporae 8-nae, simplices, ellipsoideae, incolores, longit. 9–10.5, crassit. 6–6.5  $\mu$ , pariete circ. 1  $\mu$  crasso.

Medulla KHO—, Pd—.

[Pycnidia non visa.]

*Loc.*—South America: Chile, Pico de Pilque near Antuco, leg. Pöppig (Pl. Chil. III, 278 (56), in the British Museum Herbarium).

*Icon.*—Pl. 5, fig. 3 (nomenclatural type on the right).

Sufficiently distinct by reason of the dwarf habit, subcornute branches, smooth thallus, absence of annular cracks, compact medulla, negative chemical reactions, and minute eciliate apothecia. Systematically it does not appear to be closely related to any other known species. I have seen no material other than the type-specimen.

Motyka, in Lich. Gen. Usn. Stud. Monogr. 1, p. 29 (1936), lists duplicates of this number of Pöppig in Berlin and Geneva as '*Usnea aurantiacoatra*'; probably the material distributed under this number is not homogeneous.

## DOUBTFUL SPECIES.

On p. 603 of their recently published report on the lichens collected by the Second Byrd Antarctic Expedition (Ann. Missouri Bot. Gard., xxv, pp. 515–718, 1938), Dodge and Baker publish a new species from the Edsel Ford Range in Marie Byrd Land, *Usnea frigida* Dodge & Baker. The description given is as follows: 'thallus erect or prostrate, fruticose, 3–5 cm. tall, branched, eramulose, rigid, shining, black, rarely yellow at the smooth base, up to 0.7 mm. in diameter, tips acute but not attenuate, terete, glabrous, rugose or foveolate, not dichotomously branched, divaricate, branches not attenuate at the base;

cortex 20–30  $\mu$  thick, dark or black on the outside, lighter within, pseudo-parenchymatous, cells 4–6  $\mu$  in diameter; algae protococcoid, up to 10  $\mu$  in diameter, scattered in the medulla below the cortex; medulla 50–60  $\mu$  thick, of loosely woven thick-walled hyphae 2–4.5  $\mu$  in diameter, branched and anastomosing; chondroid axis elliptic in cross-section, 60  $\times$  80  $\mu$ , of densely packed longitudinal hyaline hyphae. Soralia tuberculate, hemispheric, rarely longitudinally elongate or irregular, not eroded, black when young, becoming dirty gray or yellowish'.

As no indications of the chemical reactions are given, it has been impossible to include this species in the key on p. 206. Possibly it may be identical with my *N. acromelanus* var. *inactivus* f. *picatus*, although from the cross-section figured by the authors the medulla appears to be as lax as in *N. sulphureus*.

#### ACKNOWLEDGMENTS.

In the first place, my gratitude is due to the Trustees of the British Museum (Natural History) for a grant of money and special leave whereby I was enabled to visit Helsinki and Turku and study material in the herbaria of Acharius and Vainio. I express my cordial thanks to Prof. Dr. K. Linkola, Prof. Dr. R. Collander (Helsingin Yliopiston Kasvitieteellinen Laitos), Prof. Dr. Wariss, and Mrs. Suoma Valle (Turun Yliopisto), for their kindly help in connexion with my herbarium studies at Helsinki and Turku respectively. Type-material was received on loan from the following, to whom I express my best thanks: Hofrat Prof. Dr. K. Keissler (Botanische Abteilung des Naturhistorischen Hofmuseums, Wien); Signora Dr. M. Cengia Sambo (Prato, Firenze); and Dr. G. L. Wittrock (New York Botanical Garden). I am grateful also to Dr. Gerhard Benl (München) for his kind attempt to procure for me an exsiccata unobtainable in the British Isles.

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#### EXPLANATION OF THE PLATES \*.

PLATE 5.—Fig. 1. *N. ciliatus* (Nyl.) Kphbr. Specimen in the British Museum herbarium from the classical locality in New Zealand, coll. Sinclair (the typical form). Fig. 2. *N. trachycarpus* Stirt. Specimen in the British Museum herbarium from Kerguelen, coll. Eaton (the typical form). Fig. 3. *N. perpusillus* M. Lamb. The type-material (nomenclatural type on the right). Fig. 4. *N. sulphureus* (Koen.) Hellb. Specimen from S. America, Ecuador, Pichincha Volcano, coll. Jérémie, in the British Museum herbarium. Fig. 5. *N. acromelanus* (Stirt.) M. Lamb, var. *decipiens* M. Lamb. The type-material (nomenclatural type on the left). Fig. 6. *N. acromelanus* (Stirt.) M. Lamb var. *inactivus* M. Lamb f. *scabridulus* M. Lamb. Portion of the thallus of the type-specimen four times natural size. Fig. 7. *N. ciliatus* (Nyl.) Kphbr. var. *subpolaris* M. Lamb. The type-material (nomenclatural type on the left; on the right an older specimen).

PLATE 6.—Fig. 8. *N. antarcticus* (Du R.) M. Lamb. Three plants from the same collection from the South Shetlands (British Graham Land Expedition, no. 1400), showing variation in the form of the soredia. Fig. 9. *N. antarcticus* (Du R.) M. Lamb. Specimen in the British Museum herbarium from the classical locality in South Victoria Land, coll. Borchgrevink's *Southern Cross* Expedition, 1900 (the typical form). Fig. 10. *N. antarcticus* (Du R.) M. Lamb. Portion of a fruiting specimen (the type of "*Usnea sulphurea* var. *granulifera*" Wain.), showing apothecia and soredia; three times natural size. Fig. 11. *N. trachycarpus* Stirt. The type-material in herb. Stirton. Fig. 12. *N. antarcticus* (Du R.) M. Lamb f. *sorediifer* (Cromb.) M. Lamb. The type-specimen from Kerguelen.

PLATE 7.—Fig. 13. *N. ciliatus* (Nyl.) Kphbr. Specimen in herb. Vainio from Tierra del Fuego. Fig. 14. *N. acromelanus* (Stirt.) M. Lamb var. *inactivus* M. Lamb. Part of the type-material (nomenclatural type on the left). Fig. 15. *N. substrigosus* M. Lamb. The type-specimen from the Falkland Islands.

PLATE 8.—Fig. 16. *N. Taylora* (Hook. fil.) Nyl. Type or syntype material in the British Museum herbarium from Kerguelen. Fig. 17. *N. insularis* M. Lamb. The type-specimen from the Prince Edward group, Marion Island. Fig. 18. *N. aurantiaco-ater* (Jacq. emend. Mot.) M. Lamb f. *nigropallidus* (Ceng. Samb.) M. Lamb. The type-specimen from Tierra del Fuego.

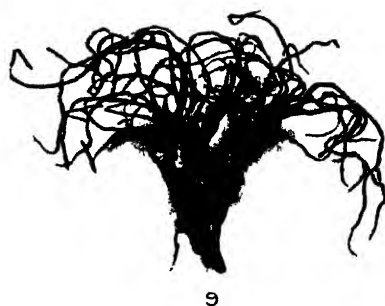
\* Unless otherwise stated, the figures on these Plates are natural size.



*Neuropogon melaxanthus* Hyl  
*Ulex melaxanthus* Ach  
 Scories du volcan de Fichincha  
 près Luto (Equateur)  
 H. H. H. H.



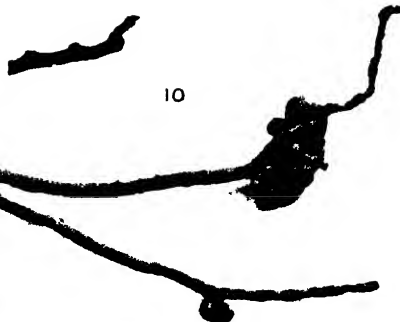




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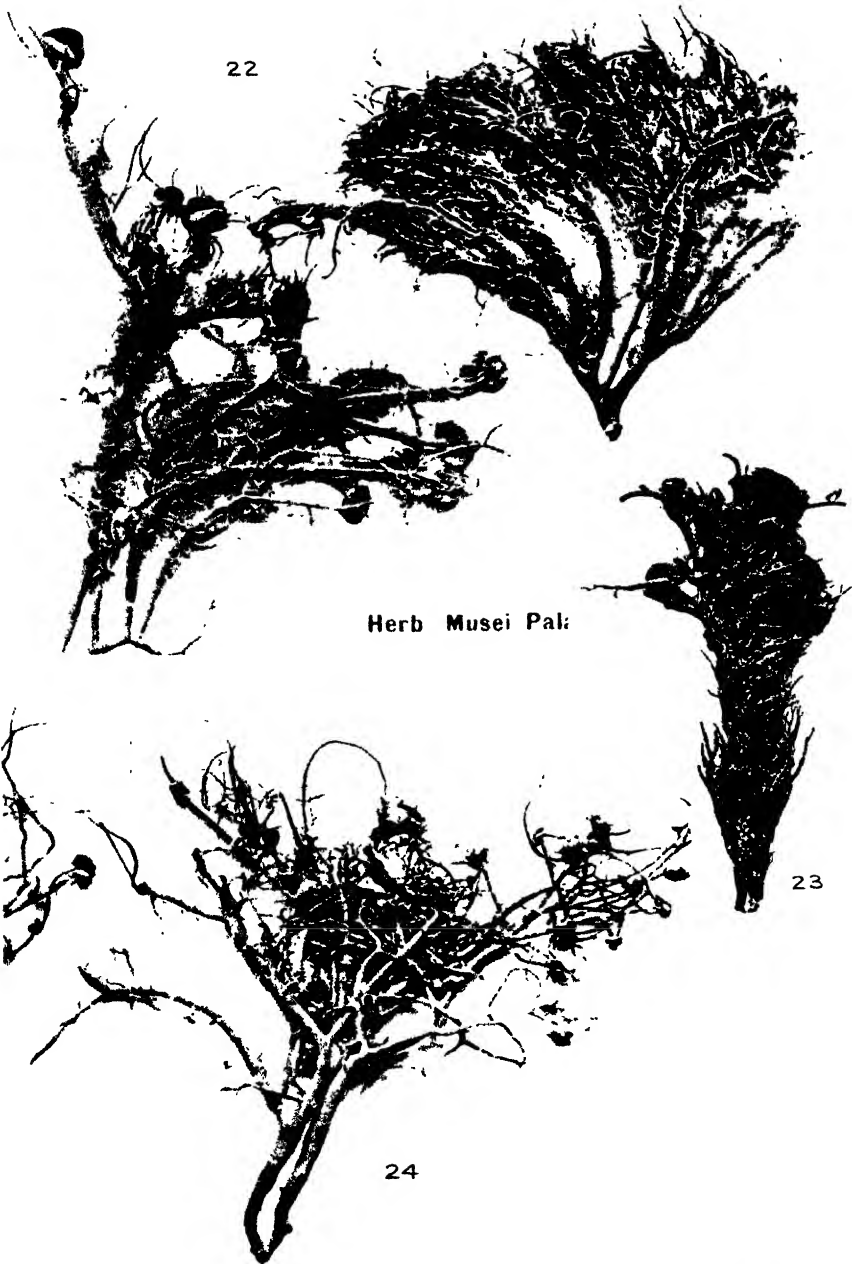




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*America*  
*Port Egmont.*  
*Lawsonville*

*Nootka Land.*



*Usnea melaxantha.*

John Bale Sone & Curnow Ltd London



PLATE 9.—Fig. 19. *N. melaxanthus* (Ach.) Nyl. f. *spadiceus* (Zahlbr.) M. Lamb. The type-specimen from the West Falkland Islands. Fig. 20. *N. aurantiaco-ater* (Jacq. emend. Mot.) M. Lamb f. *normalis* (Wain.) M. Lamb. Specimen from the Argentine group, Galindez Island, coll. British Graham Land Expedition, no. 1340 p. p. Fig. 21. *N. acromelanus* (Stirt.) M. Lamb var. *inactivus* M. Lamb f. *picatus* M. Lamb. The type-material from South Victoria Land (nomenclatural type on the left).

PLATE 10.—Fig. 22. *N. strigulosus* (Zahlbr.) M. Lamb. The type-material from Patagonia, coll. Neumann. Fig. 23. *N. aurantiaco-ater* (Jacq. emend. Mot.) M. Lamb. The type-specimen of "*Usnea fasciata*" Torrey, from the South Shetlands. Fig. 24. *N. strigulosus* (Zahlbr.) M. Lamb f. *subciliatus* (Zahlbr.) M. Lamb. Part of the type-material from Patagonia, coll. Neumann.

PLATE 11.—Fig. 25. *N. melaxanthus* (Ach.) Nyl. Aged specimens of abnormal appearance (Lechler, Pl. ins. Maclov., no. 69 b, in the British Museum herbarium). Fig. 26. *N. antarcticus* (Du R.) M. Lamb. Specimen from the Argentine group, Galindez Island, coll. British Graham Land Expedition. Fig. 27. *N. acromelanus* (Stirt.) M. Lamb. Part of the type-material from New Zealand, in the British Museum herbarium. Fig. 28. *N. melaxanthus* (Ach.) Nyl. The type-material in herb. Acharius (nomenclatural type on the left).





Studies in the Capparidaceae.—II. Floral anatomy and some structural features of the Capparidaceous flower \*. By T. S. RAGHAVAN, M.A., Ph.D., F.L.S., F.R.M.S., University Professor of Botany, Annamalai University, Annamalainagar, S. India.

(With PLATE 12, and 76 figures in the text)

[Read 19 January 1939]

#### GYNANDROPSIS PENTAPHYLLA DC.

*Gynandropsis pentaphylla* is a very common weed of waste lands of south India, where it occurs in association with the closely allied *Cleome viscosa*. There are six stamens, the filaments being adnate below to the slender gynophore. These structures are borne on the top of a gynandrophore (text-fig. 1). A close examination of hundreds of flowers on many plants has disclosed the presence of a variable number of flowers in each inflorescence in which the ovary possesses no gynophore, so that it is situated sessile on the top of the gynandrophore on a level with the base of the filaments (text-fig. 2). Such ovaries are very small, and sections of these which were taken in connection with my morphological and cytological work (Raghavan, 1938 *b*) have shown that these are completely sterile, only vestiges of ovules being present. Pl. 12, fig. 5, is a photomicrograph of a transverse section of such an ovary. These flowers are therefore to be regarded as functionally staminate. This Table shows the number of plants

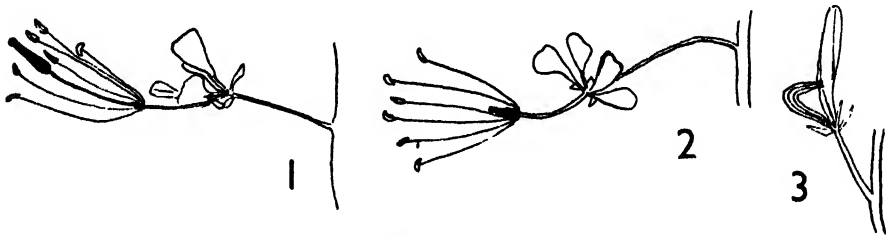
No. of inflorescence-axes per plant.	No. of plants examined.	Average no. of fertile ovaries per plant.	Average no. of sterile ovaries per plant.
1	172	8	8
2	104	16	18
3	24	30	33
4	32	32	32
5	24	35	46
6	16	70	59
8	8	74	70
10	8	61	118

Summary: Total no. of plants examined, 388. Average no. of inflorescences per plant, 5. Average no. of fertile ovaries per plant, 41. Average no. of sterile ovaries per plant, 48.

\* Being the fourth part of a thesis for the degree of Doctor of Philosophy of the University of London, and a sequel to 'Studies in the Capparidaceae.—I. The life-history of *Cleome Chelidonii* Linn. fil.' in *Journ. Linn. Soc. Lond., Bot.* LI, pp. 43-72: 1937.

and the number of inflorescences that were examined to ascertain the frequency of the occurrence of these staminate flowers. There is practically no plant nor even an inflorescence but contains a variable number of these flowers. This is not therefore a casual feature, but one of constant occurrence, and should find a place in the description of the species. The inflorescence is best described as andromonoecious. I have examined a number of specimens of this species from different localities, in the Kew herbarium and I find these staminate flowers in all of them. But in other species of *Gynandropsis* no such flowers could be made out. This is therefore to be considered as a specific character.

The method of release of the stamens from the flower bud of this species and others of the Cleomoideae seems worthy of casual mention. The flower is protandrous, and the stamens come out of the bud while the petals are yet unopened. The gap between the anterior pair of petals is greater, and through this the



FIGS. 1 & 2.—The flower of *Gynandropsis pentaphylla*. 1, the normal bisexual flower with its ovary on a gynophore. 2, a flower with its ovary rudimentary and sessile. 3.—*Cleome spinosa*, bud showing the method of release of the anthers. The petals range themselves on the posterior side while the androecium and gynoecium are on the anterior side.

stamens come out *en masse*, by the filaments undergoing an extreme expanded curvature and subsequent straightening. On account of this the stamens with the included ovary and gynophore, if any, in the Cleomoideae look depressed in a direction anterior to the floral axis, while the petals range themselves in the posterior position. Text-fig. 3 is that of *Cleome spinosa*, in which the curvature of the filaments prior to the release of the stamens from the floral bud is seen. Burkill (1916) has recorded that in *Gynandropsis pentaphylla* DC. the stigma is thrust out of the closed petals and so exposed before the anthers. The petals are said to expand subsequently, thus exposing the stamens.

Typically the ovary is composed of two carpels with parietal placentae from which arise two rows of ovules. Each carpel is held to be an inrolled foliar organ from whose incurved fertile margins the ovules originate. The place of fusion of the inrolled margins of the two carpellary leaves constitutes the so-called placenta. That this is so is seen in very young ovaries, serial sections of which show the place of union of the two carpels. Higher up

and in slightly older ovaries this becomes obscure, and the united region of the margins of the two carpellary leaves appears as a flat protuberance, the so-called placenta or commissure from whose sides the ovules arise. Pl. 12, figs. 1 & 2, show sections of very young ovaries on one side of which the fusion of the margins of the two carpels is seen very clearly at 'a'. Still more clearly is this condition apparent in *Capparis flexuosa* (Pl. 12, figs. 6 & 7).

In Pl. 12, fig. 6, which represents a transverse section of a very young ovary, the two individual carpels are seen yet in an unfused condition. The carpels, as has been shown in *Cleome helidonii* in a previous paper (Raghavan, 1937), arise laterally as papillae from the domed apex which remains after the stamen primordia have been initiated. These two roll inwards till their edges fuse, forming a unilocular bicarpellary ovary. These figures of *Capparis flexuosa* (Pl. 12, figs. 6 & 7) ovary represent such a young stage when the inrolled margins have not yet touched one another.

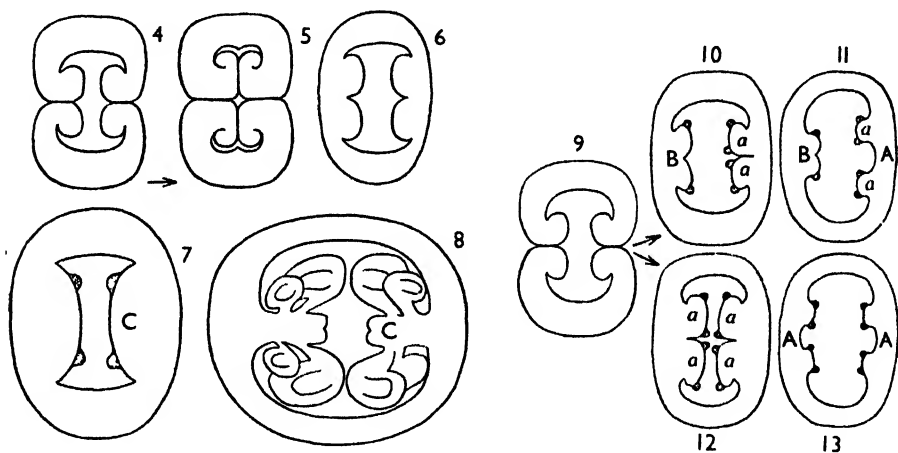
Not infrequently there appear ovaries in *Gynandropsis* which seem to contain either three or four parietal placentae, and hence at first glance should be construed to be made up of as many carpels (Pl. 12, figs. 3 & 4). But in all such cases it is a feature of never failing occurrence that the distance between the two adjacent placentae forming a loculus is not the same in the different carpels. In other words, the loculi are not all of equal size. In a tricarpeal ovary two are of equal size (Pl. 12, fig. 3), while the third is definitely smaller. In what appears to be a tetracarpeal gynoeceum, diagonally opposite loculi are of equal size, and one pair is definitely smaller than the other (Pl. 12, fig. 4). These variants may be interpreted as follows:—Normally the gynoeceum is formed by the marginal fusion of the carpellary leaves. If we imagine that on one side the fusion is complete whilst on the other the extreme tips of the incurved margins of the carpellary leaves remain unfused, then the further growth in girth of the unfused upper portion will naturally result in the separation of these two margins. So while on one side the placenta represents the fused product of the two carpellary margins (Pl. 12, fig. 3 at *b*), the margins on the other side have been widely separated on account of the incomplete fusion and the production of a secondary tissue (Pl. 12, fig. 3, *a*). According to this interpretation the former is to be regarded as a normal placenta or commissure while the other two are the margins of the unfused carpels. If this interpretation is correct, the gynoeceum, although it appears at first sight to be made up of three carpels, is formed by two carpellary leaves only. This interpretation is further strengthened by the fact that the separated margins of the two carpels constituting the two adjacent placentae, whose loculus is smaller than the other two (Pl. 12, fig. 3, *a*), are narrower than the other placenta, which has arisen obviously from a fusion of the adjacent margins of the two carpels (Pl. 12, fig. 3, *b*). In fact, the latter is nearly double the size of the former.

Similarly the other gynoeceum, apparently in the tetracarpeal condition, may be interpreted as derived from an incomplete fusion or a failure of fusion of the ends of the two carpels. Hence it is that one finds that the two loculi

(situated opposite to one another) formed or bounded by each individual carpellary leaf are equal in size and bigger than the other two, which represent the tissue that has been intercalated between the margins of the two adjacent carpellary ends whose failure to fuse has rendered this possible (Pl. 12, fig. 4). This interpretation of the condition has been represented diagrammatically in text-figs. 4-8 and 9-13. On this basis, therefore, these gynoeceia have to be termed bicarpellary, since it is assumed that only two carpels have entered into their constitution.

The following two paragraphs explain the diagrammatic figures 4-8 and 9-13.

Figures 4 to 8 give a diagrammatic representation of the formation of the Capparidaceous gynoeceium. Various stages in the marginal fusion of the two inrolled carpellary leaves are represented, and the ultimate structure such



FIGS. 4-8 and 9-13; for explanation see text.

as is met with in the gynoeceium of *Gynandropsis pentaphylla* is represented in the last figure of the cycle. It should be noted that the diagrammatic representation of the two carpellary leaves composing the gynoeceium is identical with the photomicrograph represented in Pl. 12, fig. 6, of the two carpellary leaves which make up the gynoeceium of *Capparis flexuosa*, and also that the commissural region (C) which according to the polymorphic theory represents the solid fertile carpel is nothing more than the fused product of the two adjacent carpel margins.

Figures 9 to 13 give a diagrammatic representation of the derivation of the apparently tricarpeal and the tetracarpeal gynoeceia occasionally met with in *Gynandropsis pentaphylla*, from the two carpellary leaves which primarily enter into the formation of the gynoeceium. Starting from the two carpels represented on the left the series of diagrams on the top show the derivation

of the 'tricarpellary' condition. At *B* the two carpellary margins fuse completely, while at *A* the fusion is incomplete, so that as the ovary gets older the two carpellary margins, *a*, become widely separated by the intercalation of a secondary tissue, *A*. Note that *B*, representing the true commissure formed by the marginal fusion of the two carpellary leaves, is twice as broad as *a*, each of which represents only one of the carpellary margins. Compare this with the photomicrograph represented in Pl. 12, fig. 3.

In the bottom the derivation of the 'tetracarpellary' condition is indicated. Here the carpellary margins, *a*, do not fuse at both ends, so that the adjacent carpellary margins become separated, as the ovary grows older, by the intercalation of the secondary tissue, *A*. Note that diagonally opposite loculi are of equal size. The loculi, *A*, are smaller, being the secondary tissue separating the two carpellary margins, while each of the other two loculi are formed by each of the two carpellary leaves. Compare this with the photomicrograph Pl. 12, fig. 4.

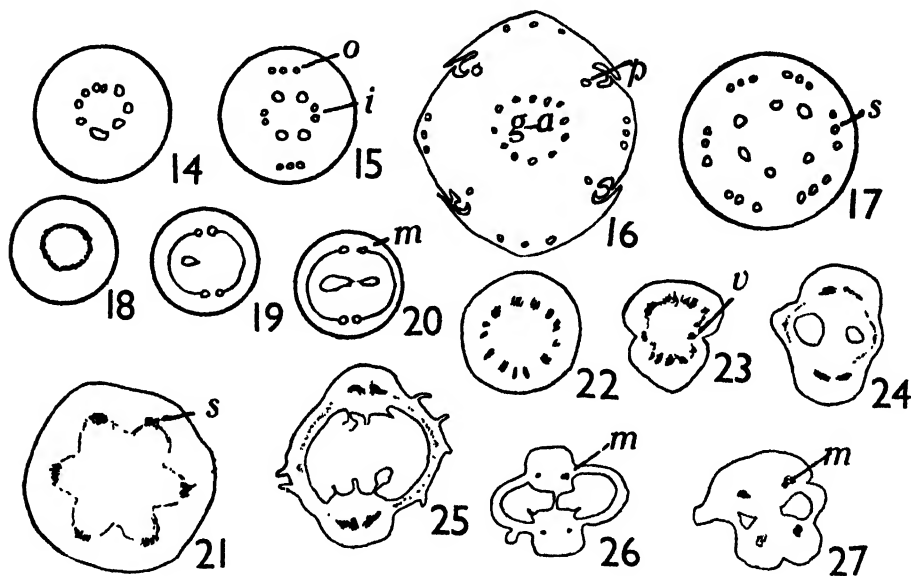
*Anatomical.*—Figs. 14–20 represent diagrammatically transverse sections from a series passing through a flower-bud of *Gynandropsis pentaphylla* from the pedicel upwards. The vascular skeleton of the pedicel consists of about eight bundles. The ring of bundles is broken by the outward passage of the strands of the median pair of sepals. It will be seen from text-fig. 15, *o*, that while the strands of the median pair of sepals have already reached the cortex, the vascular supply for the lateral pair of sepals, *i*, has scarcely left the central cylinder. The sepal strands branch as they approach the periphery and during the growth of the bud.

When the sepal supplies have left the central column, there remains a rough circle of vascular tissue in the floral axis, the gap left by the outer (median) sepal strands having been bridged. In text-fig. 16, *p*, four bundles for the petals are passing out of the ring in the diagonal planes. The primary supply to each petal consists of one bundle which branches twice or thrice during the growth of the organ. Arber (1931 *a*) finds in the Cruciferae that each petal bundle gives off two bundles, of which one enters the margin of the adjacent outer and the other the margin of the adjacent inner sepal, so that the lateral veins of the sepals originate from the petal strands.

The lateral veins of the sepals are derived from a branching of the primary sepal supply. The petals having been accounted for, there remains in the centre of the flower-bud an irregular and broken ring of vascular tissue, which contains the supplies for the stamens and for the gynoecium (fig. 16, *g-a*). The primary supply to each of the six stamens consists of three strands (fig. 17, *s*). The departure of the stamen bundles leaves six gaps in the cylinder, separating six vascular groups lying in the planes of the valves and the commissural region. At a slightly higher level the gaps are bridged and an unbroken ring of vascular tissue is seen (fig. 18). Still higher up one of the loculi makes its appearance, bounded by the valve of a carpel (fig. 19). The vasculature of the latter consists of a number of small strands, and the marginal ones are slightly

more prominent (figs. 19 & 20, *m*). The other carpellary locus makes its appearance at a higher level (fig. 20).

The fact that the ovarian cavities do not appear simultaneously at the same level but occur in a spirally alternate sequence could be correlated to the spirality of the foliage leaves and other floral members. The same sequence is followed in the termination of the ovarian cavities in the stylar region. This fact emphasizes the foliar nature of the carpels. Gregory (1936) found the



FIGS. 14-27.—*Gynandropsis pentaphylla*. 14-20. Serial transverse sections (diagrammatic) from the base of the flower-bud, in series upwards,  $\times 14$ . Note that the strands for the outer (median) sepals are the earliest to leave the central cylinder: *o*, strands for the outer sepals; *i*, strands for the inner sepals; *p*, petal strands; *g+a*, gynoecial and androecial supply. Fig. 17 represents the base of the gynophore, with the stamen strands (*s*) leaving the central cylinder. Note the gynoecial cavities making their appearance one by one in a spiral sequence in figs. 19 & 20; *m* are the marginal strands of the adjacent carpels. 21-27. Sections from the base of sterile ovary to stigma,  $\times 14$ : *s*, stamen strands; *v*, the strands of the two valves composing the gynoecium; *m*, marginal strands of the two valves.

three ovarian cavities of *Elettaria* appearing and terminating in a spiral sequence. To my mind the ring of vascular tissue that remains after the gaps left by the departure of the stamen strands have been bridged indicates at least theoretically, the termination of the axis (in this case the gynophore), from whose sides the two carpels arise. The vascular strands of the two carpels, though they appear to be directly continuous with this ring, have to be regarded as traces arising laterally from them, inasmuch as the two carpels originate as lateral

foliar members (Raghavan, 1937). The vasculature of the carpels is essentially that of any lateral appendage, leaf or leaf-like structure, which has been modified to a great extent to cope with the highly specialized function. But whereas in a normal foliage leaf there is usually one median strand representing the midrib and other lateral veins, here the marginal bundles are the more prominent, and this is not hard to explain, for they supply the placental region from where the ovules originate. As Eames (1930) says, the fact that the lateral veins are stronger than the midrib is due to the fact that the former are strengthened by the physiological demands of the ovule and seed development. This absence of vascular tissue in the midrib position and its presence as one vascular bundle where the margins of the two carpels meet led Spratt (1932) to believe that in the Cruciferae the commissural bundles really correspond to the midrib bundles, and that the ovules are borne from the midrib of the carpels rather than from the margins. For this, however, there is no evidence, for not only are there very often two bundles at the commissure representing the two bundles of the adjacent carpels, but in *Capparis flexuosa* (Pl. 12, figs. 6 & 7) I have actually seen in a very young gynoceium two inrolling carpellary leaves of the type represented in fig. 4 of Spratt's paper.

*The sterile ovary.*—After the departure of the bundles of the stamens (fig. 21, s) there remains a vascular ring (fig. 22). At the level of the separation of the vascular strands there is a groove (fig. 23) on either side of the ovary, and as these strands of the two valves migrate to the periphery these grooves are replaced by projections (fig. 24) and the ovarian cavities make their appearance one by one. The valves are thus differentiated and the two cavities are merged into one (fig. 25). All the vascular bundles except the commissural ones representing the marginal bundles of the adjacent carpels become obscured, and the double nature of the bundles is quite apparent (figs. 26 & 27). Pl. 12, fig. 5, is a photograph of the top portion of a sterile ovary. The two bundles on each commissure (*m*) are the marginal bundles of the adjacent valves and the septum joining the two commissures is also clearly seen.

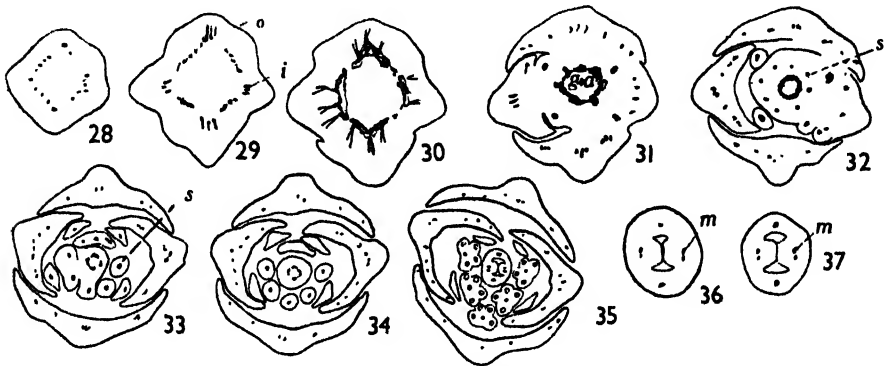
#### EUADENIA EMINENS Hook. f.

I am indebted to Mr. M. Y. Orr, of the Royal Botanic Gardens, Edinburgh, for fixed material of flower-buds and ovaries. When the investigation was nearing completion the plants in the Royal Botanic Gardens, Kew, came into flower, and I was kindly permitted by the Director to use them in my work. The inflorescence is corymbosely candelabriform, each flower being subtended by a bract. In addition, there are two very small bracteoles transversely placed at the base of the pedicel. Of the four petals the posterior ones are extremely long and spathulate. There are five fertile stamens arranged in a semicircular manner in the anterior half of the flower, while in the posterior portion there are three staminodes united into a strap-shaped body.

There is a ring of vascular bundles (fig. 28) which is broken by the outward passage of the strands of the anterior-posterior sepals, which therefore should



be understood to arise first (fig. 29, *o*). The primary supply to each sepal consists of three vascular bundles, each of which sends out two branches (fig. 30). When the sepal supplies have left the central column there remains a rough circle of vascular tissue. This is divided into four unequal parts by the separation of the petal supplies (fig. 31), which migrate from the centre, alternating with the sepals. The remaining groups of vascular tissue contain the supplies for the stamens and the gynoecium (fig. 31, *g* & *a*). The departure of the eight stamen strands leaves as many gaps in the central vascular stele. In text-fig. 32 eight stamen strands have separated and the central stele has assumed a more or less unbroken ring-like form, the gaps having been bridged. It must be remembered that there are only five fertile stamens, so that the staminal strands are separated for the three staminodes also, though they die out before

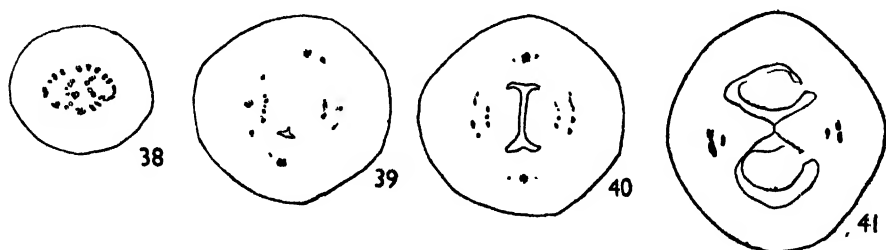


FIGS. 28-37.—*Euadenia eminens*. Transverse sections at successively higher levels from the top of the pedicel to the ovary of a very young flower-bud,  $\times 10$ . Note eight stamen bundles separating from the central stele (figs. 32 & 33, *s*), three of which die out before reaching the apex of the filaments (fig. 34). Note also the dual nature of the marginal bundles (*m*) and the appearance and disappearance of the ovarian cavities in a spiral sequence.

reaching the apex of the filaments. Arber (1933) has recorded a similar condition in *Antirrhinum*. The posterior stamen of *A. majus* is represented by a short antherless filament, and by serial sections she found that the bundle died out before the apex of the filament was reached. In *Digitalis purpurea* (Arber, 1932) the rudiment of the posterior stamen was much smaller, and she found no corresponding vascular bundle at all. Figs. 33-35 represent the separation of the stamens and the barren stamens and the residual vascular tissue which is originally broken up into groups (text-fig. 33) assumes again a ring-like form (text-fig. 34). From this arise the supplies for the two carpels, three for each carpel, one midrib and two marginal strands. The duality of the marginal strands becomes quite apparent at slightly higher level where the cavities are appearing in a spiral sequence (figs. 36 & 37). It is of interest to note that the

two carpels are situated in the anterior-posterior plane, and not laterally as in the rest of the family. That is, the commissures, instead of being antero-posterior, are transversely situated.

*Older ovary.*—Figs. 38–41 are transverse sections of the ovary at successive higher levels from the base. Fig. 38 shows a transverse section of the top of



FIGS. 38–41.—*Euadenia eminens*. Serial transverse sections of mature ovary from base upwards. Note the origin of the so-called placental strands.

the gynophore at the base of the ovary. The strands in the central region represent what at a higher level become the extreme marginal bundles of the incurved tips. These evidently arise as small minor branches from the other carpellary strands, and at a higher level the strands of the adjacent carpels fuse, forming the so-called placental strands internal to the marginal strands and supplying the ovules (figs. 40 & 41). The marginal bundles of the carpels are concentric, as also the bundles of the filaments (fig. 37). Such amphiphloic bundles have been recorded by Arber (1931 *a*) in the ovule bundles of *Raphanus*



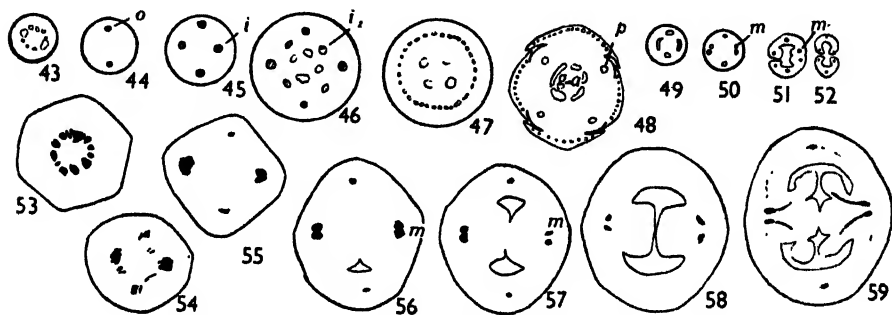
FIG. 42.—*Euadenia eminens*. The concentric nature of the marginal bundle of the carpel,  $\times 500$ .

and the petal bundles of *Lunaria*. According to Arber (1930) a concentric bundle is a single strand and is to be looked upon as a mere variant of the collateral type rather than a result of bundle fusions.

#### CAPPARIS FLEXUOSA Blume.

I am indebted to the Director of the Royal Botanic Gardens, Kew, for material of this species which is a native of Java. Figs. 43–48 represent diagrammatically transverse sections from a series through a very young flower in which the ovular primordia have not yet been initiated. In fig. 43, representing the pedicel

at the base of the flower, there is a ring of vascular bundles of unequal size. As in the previous cases, the strands for the median pair of sepals are the earliest to separate (fig. 44, *o*), and they are soon followed by those of the lateral sepals (fig. 45, *i*). The outward passage of these leaves the stele in the centre in the form of irregular vascular masses. These are followed by four more strands alternating with the former (fig. 46, *i*<sub>2</sub>), and these on coming to the periphery form a ring of vascular tissue in connection with the other four (figs. 47 & 48), and these form the sepal supply. The gaps are bridged and the four petal strands are the next to differentiate (fig. 48, *p*). This migration leaves four outstanding groups of vascular tissue, which contain the supply for the stamens and the gynoecium (fig. 48, *g+a*). When the staminal whorls have been differentiated there remains in the centre of the flower axis a mass of vascular tissue from which the gynoecial strands are differentiated (fig. 49),



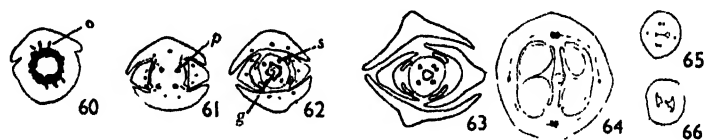
FIGS. 43-59.—*Capparis flexuosa*. 43-52. Serial sections from the base of a very young flower-bud to stigma,  $\times 12$ . *o*, strands for the outer sepals; *i*, strands for the inner sepals; *i*<sub>2</sub>, second set of strands which, moving to the periphery, forms a ring (figs. 47 & 48); *p*, petal strands. 53-59. Transverse sections of an older ovary at successively higher levels. Note the duality of the marginal strands (*m*) and also how they supply the ovules directly (fig. 59).

three strands for each carpel, one dorsal and two ventrals. The dorsal constitutes the midrib, while the ventrals are the marginal strands. The two marginal strands are more or less fused into one principal strand at a lower level and upwards, when the identity of the two carpels could be seen very distinctly the individual marginal strands of the respective carpels are unmistakably distinguished (figs. 50-52). The sections of ovary of this species at a very young stage of development, when the two inrolled carpels are just beginning to fuse along their margins (figs. 51 & 52 and Pl. 12, figs. 6 & 7) show beyond doubt the bicarpellary nature of the gynoecium. The vasculature of the two carpels composing the gynoecium corresponds to that of a lateral appendage, leaf or leaf-like structure. It is to be noted that there is no trace of the so-called placental strands internal to the marginal bundles of the adjacent carpels which constitute the commissural bundles.

*Older ovary*.—Serial sections of a much older ovary confirm the observations made previously and are particularly convincing in view of the absence of any secondary vascular structure. At the base of the ovary is a ring of vascular strands from which the carpels arise laterally (text-fig. 53). The marginal bundles (text-fig. 56, *m*) are prominent right from a low level, and their duality becomes distinct at a stage when the loculus of the ovary is completely differentiated (text-figs. 56–59). As in the previous cases, the ovarian cavities appear and disappear in a spirally alternate series. The marginal strands and the midrib of each carpel are connected by a number of minute strands (text-fig. 59). The marginal bundles constituting the commissural bundles send out principal strands directly to the ovules.

#### CADABA INDICA Lam.

From a solid ring of vascular tissue (fig. 60) three strands for each of the two median sepals are the first to leave. These overlap completely the two lateral sepals, which are smaller than the former (fig. 61). The four petals which



FIGS. 60–66.—*Cadaba indica*. Sections through the flower,  $\times 30$ . *o*, outer sepal strands; *p*, petal strands; *s*, stamen strands; *g*, gynoecial strands. In fig. 63 five staminal strands are seen. Note the formation of the septum in fig. 66 and how it forms a replum in fig. 64. Note in the figure the region of loose cells in the middle of the replum. The duality of the marginal bundles in fig. 64.

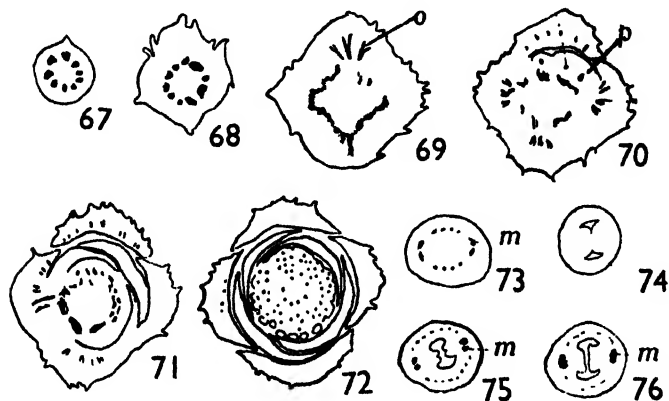
alternate with the sepals are very small, and the supplies for these are the next to leave (fig. 61, *p*). The number of stamens is usually four (fig. 62, *s*), for which the vascular supply is as usual. But occasionally there are five (fig. 63).

The two carpels of the ovary are differentiated in the usual manner, three strands going to each carpel (fig. 65). The commissures representing the fused margins of the adjacent carpels, though separate at a very early stage at a lower level, fuse at a higher level (fig. 66 and Pl. 12, fig. 8, *f*). As the ovary gets older the fused portion becomes elongated (Pl. 12, fig. 9, *f*), forming a septum connecting the two commissures. This is quite identical with the replum of the Cruciferae. In the centre of the replum of a mature ovary is a circular zone of loosely arranged cells (Pl. 12, fig. 10, and fig. 64).

#### CLEOME CHELIDONII Linn. f.

There are about nine vascular cords in the pedicel at the base of the flower-bud (figs. 67 & 68). Three strands for each of the two outer (median) sepals

are the first to leave (fig. 69, *o*), and these fork into two as they move peripherally. The lateral sepal supplies are the next to leave, and they behave likewise (fig. 70, *i*). The exit of these strands divides the central stele into irregular groups from which the vascular supply for the petals originate in diagonal planes (text-fig. 70, *p*). The rest of the stele represents the supply for the gynoecium and the androecium (fig. 71). The number of stamens is large and variable. The supply for each of the two carpels composing the gynoecium consists of the prominent marginal bundles, and there is no well-marked midrib (figs. 73–76, *m*). Instead there are a number of minor vascular strands forming the vascular



FIGS. 67–76.—*Cleome Chelidonii*. Sections through the flower,  $\times 30$ . *o*, strands for the outer sepals; *p*, strand for the petals; *i*, strand for the inner sepals; *m*, marginal strands. Note their duality. Note also the spiral disposition of the staminal strands and the absence of a prominent mid-rib in the valve region.

skeleton of the valves. The individual carpels could not be seen so distinctly as in *Capparis flexuosa*, but their duality could be made out none the less (text-fig. 75) by the bifid nature of the commissure representing the fusion of the carpels along the margins.

#### DISCUSSION.

*The 'outer' sepals.*—The plan of the Capparidaceous flower is admittedly identical with that of the Cruciferae except for the androecium. There are two outer median and two inner transverse sepals, and four petals arranged diagonally. Practically no literature is available on the organogeny of the Capparidaceous flower except the work of Payer (1857). But its close identity with the Cruciferous flower and the controversy that exists in respect of the position of the outer pair of sepals of the latter are made use of in the elucidation of the point under discussion. The Capparidaceae, like the Cruciferae, are

supposed to possess no bracteoles (Rendle, 1925, p. 172), and this has an important bearing on the position of the earliest members of the floral whorls, i.e. the outer. According to Rendle (1925), though sometimes bracteoles may be traced in young flowers, evidence of their existence at some time in the history of the family is to be found in the position of the outer whorl of sepals, which are median and not lateral as we should expect them to be in the absence of bracteoles. This is in accordance with the account of the Cruciferous flower as given by Čelakovsky (1895). Arber (1931 a), on the other hand, has shown that the lateral sepals are actually the first of all the floral members both in their detachment and in the origin of their median bundles, and that the median sepals enwrap the margins of the lateral sepals even before the former are free from the axis. The fact that the lateral sepals are the lower, according to her, removes the difficulty of the median placing of the first floral members.

In all the plants that have been studied in this paper it is the antero-posterior sepals that are seen to be detached first, and the median strands for these sepals are the first to break away from the stele of the pedicel. It is therefore likely that the evidence for the existence of the bracteoles at some stage in the history of the family is to be found in the median placing of the outer whorl of sepals. Moreover, I have examined some of the Capparidaceous plants that happened to be in flower at Kew Gardens, and I find that bracteoles are actually present in two of the genera, though they are extremely small and fall off quite early. The species in question are *Capparis flexuosa*, a Javanese member of the family, and *Euadenia eminens*, a native of West Africa. In view of this and of the decisive median placing of the outer sepals I do not think it right to regard the flowers of the Capparidaceae as devoid of bracteoles.

*The gynoeceium.*—The commonly accepted view of the siliqua is that it is composed of two lateral vasculated carpels, and that the two smaller vasculated arcs are inward prolongations of the incurved fertile margins of the two carpels; these become united centrally to form the replum, which is a feature of constant occurrence in the Cruciferae but which in the Capparidaceae is only seen occasionally, as in *Cadaba indica* and in some species of *Cleome*. But various degrees of fusion and meeting of the edges of what may be called the commissural tips are seen in the different genera.

The attention of Saunders (1923) was originally attracted by the occurrence of *Matthiola* fruits differing from the usual siliqua in the possession of a longitudinal wing-like structure extending the whole length of the siliqua and showing transverse fissures, as though the tissues had been torn apart. They had four valves alternating and united with four smaller vasculated arcs, instead of the usual two. From these and other variations she considered the unusual fruits as atavistic rather than abnormal, and postulated the theory of carpel polymorphism, deriving the usual siliqua from a many-carpelled state through processes of reduction and consolidation. The same processes of reduction and consolidation are held to have operated in the Capparidaceae

(Saunders, 1923). Forms like *Capparis spinosa* are held to contain many valve and solid carpels, while in the Cleomoideae the final four-carpelled stage is supposed to have been reached, two valve and two solid. This polymorphic carpel theory has since been extended to apply to almost all families (Saunders, 1925, 1927), and the general result is that the number of carpels is increased in almost all cases. For example, *Eschscholzia*, which is usually held to possess a normal bicarpellary gynoecium, is according to this theory, made up of twenty carpels, ten solid and ten valve. The essence of the theory consists in regarding every thick fibro-vascular cord that traverses longitudinally the siliqua as the midrib of a once functional valve carpel. By reduction and consolidation all the minor bundles except the midrib have disappeared, and this consolidation, since it is held to take place symmetrically, results in forms like *Eschscholzia* assuming a compound valve composition, by which the structure, though simulating ordinary valves, is held to be composed of numerous sterile solid and valve members alternating with one another.

Eames and Wilson (1928, 1930) reach a somewhat similar conclusion regarding the Cruciferous gynoecium. They regard (1928) the general structure of the ovary in the Capparidaceae as similar to that of the Cruciferae, differing chiefly in the absence of the septum. They believe in the presence of a pair of sterile valve carpels and a pair of fertile carpels, but they derive them in a different way, for while Saunders merely postulates their presence, these authors indicate how the solid carpel may have arisen. According to them the venation of the commissure represents a complete vascular supply of a valve carpel, which has become so compressed that the loculus has been lost and become solid, squeezing out the ovules in doing so. So much is this the case that the sterile valve carpels are held to be placed below the other two carpels and to enclose the latter. The second set of carpels, fertile and solid, is reduced, the loculus has disappeared, and the ovules borne by these carpels have been forced out of the loculus and lie in the loculus of the valve carpels. All the four carpels, however, are held to be morphologically and anatomically the same, a solid carpel being a modification of a carpel of the same type as the sterile carpel.

Having these authors in mind, let us see how far the ontogeny and anatomy of the six species at present investigated either corroborate or contradict a polymorphic conception of the Capparidaceous gynoecium.

*Ontogenetical.*—In *Gynandropsis*, as the photographs show (Pl. 12, figs. 1 & 2), the partial marginal fusions of the two inrolled carpels is seen clearly on one side, while on the other the fusion has been so complete that the individual carpel margins are not recognizable. In *Capparis flexuosa* the two inrolled carpels of a very young gynoecium are seen quite clearly (Pl. 12, fig. 6), and it is obvious that the commissure which is held to represent the solid carpel is composed merely of the inrolled margins of the adjacent carpels. Though this fusion of the margins, which is almost congenital, obscures the individuality of the two carpels composing the gynoecium in many cases, the structure of the

uppermost region of the ovary confirms it. The extreme apex recalls the appearance of the thickened tip of any foliage leaf. In almost all the cases we find the two individual carpels separate near the styler region. Arber (1937) has found the gynoecium of *Antirrhinum majus* to be composed of two carpels which have their margins united and also fused with those of the adjacent carpel. Serial sections of such a gynoecium at a very early stage show that the margins of each carpel come apart near the top of the ovary, and above this the two carpels separate. Such a separation has been observed in all the genera investigated in the present study. There is thus ontogenetically no evidence for the presence of more than two carpels and of the existence of any other type of carpel than the normal valve-like ones. Arber (1937), in a recent survey of some aspects of morphological thought in the interpretation of the flower, has sketched microtome sections of very young gynoecia of *Aconitum Napellus* to serve to illustrate the Candolleian theory. The carpellary margins bearing the rudimentary ovules are represented as being free from one another though appressed. Newman (1928) has adduced similar ontogenetic evidence in support of the foliar nature of the carpels of *Doryanthes excelsa*.

*Anatomical.*—The theory of Eames and Wilson (1928, 1930) rests almost entirely upon the presence of inverted placental strands in the commissural region (ventral suture). According to them these represent the ventral or the marginal bundles of the compressed solid carpels, which have lost their loculus in the process of solidification. In most of the species examined no trace of these placental strands exists in the youngest stage of the gynoecium, but in some, like *Euadenia* (text-figs. 40–42), these make their appearance at a much later stage. And it can be seen that in *Euadenia* (text-fig. 39) they originate as branches from the vascular bundles of each of the two carpels, and higher up the branches from the two adjacent carpels come together and constitute a minor array of vascular bundles internal to the commissural bundles.

In my opinion the placental strands, since they do not appear till the ovules have advanced in their development, have to be considered to arise more as a physiological response than anything else. And to attach phylogenetic importance to a piece of vasculature which is evidently secondary in its origin is misleading. Supporting the unitary foliar structure of the legume of *Acacia Baileyana* as against the polymorphic concept, Newman (1933) says that it seems reasonable to give more weight to the detailed histological evidence from the initial stages than to the plan of vasculature in the developing fruit. Parkin (1926) is also impressed with the unsoundness of basing a morphological interpretation of a fruit on its vasculature because of the secondary nature of many of its bundles. According to the same author the interpretation by Eames and Wilson of the placental strands in support of the four carpellary theory is 'putting too great a strain on them as evidence'. Apart from the absence of these from the youngest ovaries, the question how the ovules borne by a carpel come to lie outside that carpel and within the loculi of other carpels is answered by the authors (1928) by the assumption that their position



is false or a derived one. They (1930) maintain that Crucifer ovules are borne exogenously as any Angiosperm ovules, but that they have become extruded from the loculus. Their explanation that this extrusion has occurred directly through the wall 'phylogenetically, not ontogenetically', is not convincing. How an organ which in its vascular ontogeny is held to recapitulate its phylogenetic history could ever fail to give a clue in the matter of the extrusion of the ovules is hard to understand.

Saunders' evidence for the increased number of carpels is derived from the extra number of longitudinal parallel vascular strands in the mature ovary and fruit. Each of these is supposed to represent the remnant of the midrib of a once functional valve carpel. This statement involves the belief that a carpellary leaf is reduced to its vascular bundle alone, which means that this bundle is embedded in a tissue belonging to other carpellary leaves. How does it happen that while the rest of the carpel has been so very much reduced the vascular bundles alone persist? For such a conception one has to take the doctrine of the conservatism of the vascular bundles as an established fact. For this, however, there is no evidence. Arber (1928) has shown that in the grass *Luziola Spruceana* the rudiments of the outer empty glumes are almost non-vascular. Though a strand corresponding to each glume occurs in the axis, they die out before the glume is reached. Similar examples of the non-vascularisation of rudimentary floral leaves are also available from her work. While in *Corydalis nobilis* (Arber, 1931 b) the vascularisation of the single pair of sepals is normal, in *C. bulbosa* the equivalent pair of sepals is extremely reduced, and there is no vascular supply for them either in the receptacle or in the free part of the sepal.

In the present investigation it has been shown that the vascular supply to the rudimentary stamens of *Euadenia eminens* dies out long before the apex of the filament is reached. It is clear from these examples that 'a rudimentary external form is found to correspond to a vascular system which is equally or even more rudimentary; indeed an organ which retains some trace of its normal external form may yet show a complete lack of vascular tissue' (Arber, 1933). When such is the case there is no warrant for the assumption that the vascular cord alone has remained while the rest of the carpel is gone, as the polymorphic theory would have us believe. It is not clear, therefore, why the vascular bundles should have this significance that Saunders has attributed to them. In the words of Parkin (1933), 'to imagine nearly every stout fibro-vascular cord running longitudinally as the midrib of a carpel is surely bordering on the fantastic'.

Near the tip of the axis a ring of bundles remains after the bundles for the stamens have left. Saunders considered the four bundles remaining after the stamen traces have passed out, as the four carpel traces supplying the four carpels. These are, however, true stelar bundles (Eames and Wilson, 1928), and traces pass out from these to the two carpels. The vascularisation of each of the carpels consists generally of three bundles, typical of a foliar lateral

appendage. The dual nature of the marginal bundles at the commissure, which is clear in almost all the cases, is a sure indication that they represent the marginal bundles of the adjacent carpels. Arber (1937) says that not only is the shape of the carpel explicable on the Candolleian hypothesis, but the internal structure also follows just the lines which on this hypothesis might have been predicted. Instancing the anatomy of the gynoecium of *Hypericum hirsutum*, she shows three arcs of vascular tissue as being left for the gynoecium at its base after the stamen phalanges have been given off. Each of these arcs divides into three—a median strand which forms a carpellary midrib and two main laterals (marginal bundles) each of which fuses with a corresponding main lateral of an adjacent carpel. These fused laterals are said to become the placental strands. Such a description is almost identical with the evidence adduced in this paper in favour of the classical concept of the carpel. In support of the foliar concept of the carpels may be cited their lateral origin (Raghavan, 1937 a) from the domed apex of the axis, and the appearance of the loculi of the ovary in a spiral sequence, recalling the origin of any foliar member or any other floral member.

#### SUMMARY.

The paper deals with the floral structure of several genera and species of the Capparidaceae. The findings may be summarized as follows :—

The prevalence of andromonoecism is recorded in *Gynandropsis pentaphylla* DC.

The occurrence of what look like tricarpeillary and tetracarpeillary gynoecia in the species is explained and interpreted on the bicarpeillary basis.

The median sepals are found to be the lowest floral members ; thus they occupy the position which would be expected had bracteoles been present ; this view is supported by the actual occurrence of bracteoles in *Euadenia eminens* Hook. fil. and *Capparis flexuosa* Blume, and the belief that the Capparidaceae are bracteoleless is not accepted.

The vasculature of the members of the different floral whorls in all stages of development has been traced.

The ontogeny of the gynoecium shows that it is formed by the marginal fusion of two inrolled carpellary leaves.

The foliar concept of the carpels is supported by anatomical evidence, the vasculature of the carpels being essentially that of a lateral organ, leaf or leaf-like appendage.

The polymorphic carpel theory is discussed in the light of the present findings, and the conclusion is reached that it is not applicable to the Capparidaceae.

In conclusion, it is a source of sincere pleasure for me to record my grateful thanks to Professor R. Ruggles Gates for his unfailing interest in the progress of the work and for much helpful guidance.

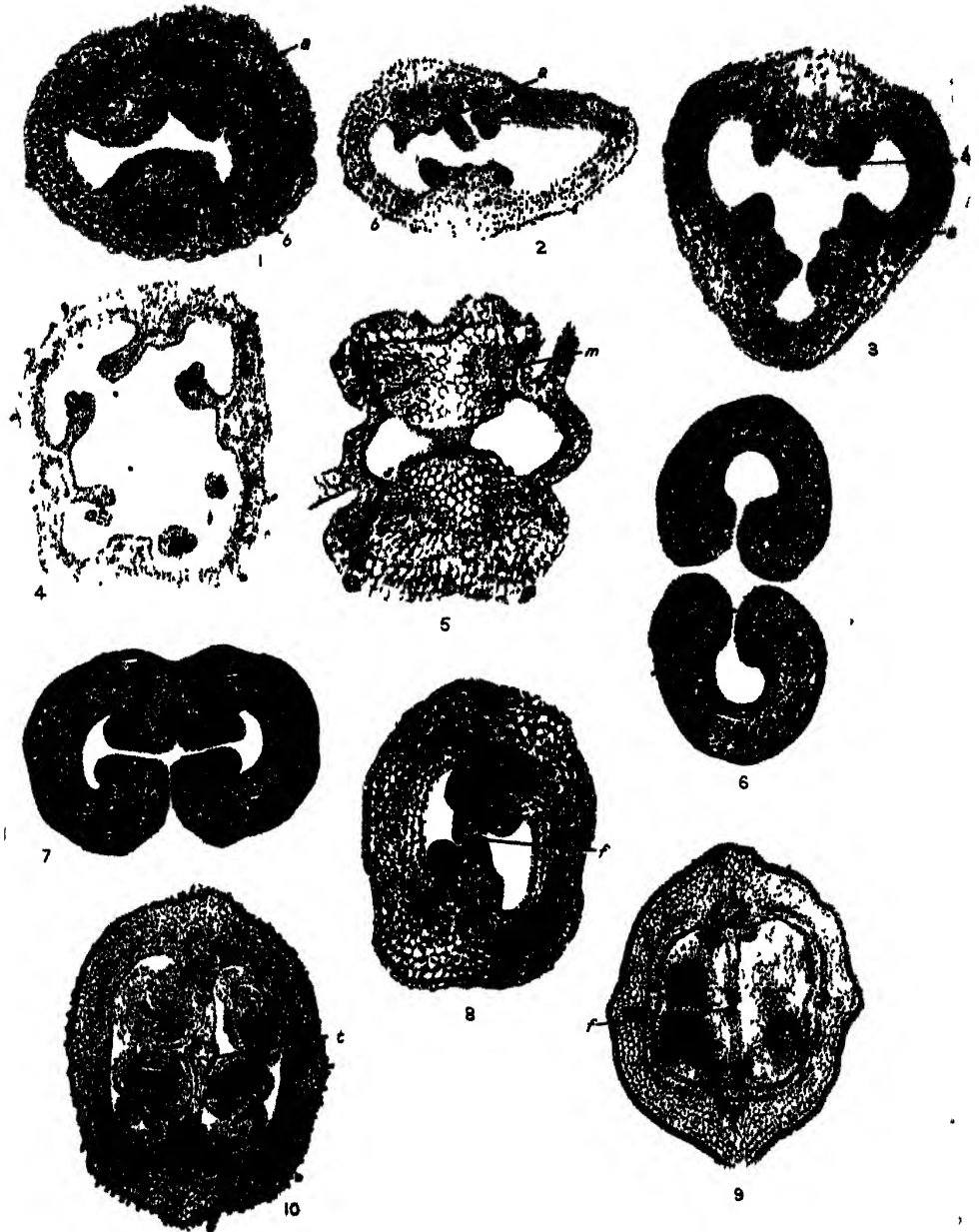
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## EXPLANATION OF PLATE 12.

Fig. 1. Transverse section of very young ovary of *Gynandropsis pentaphylla*. At b the fusion of the two carpellary margins is complete, while at a it is incomplete and the individuality of the carpel margins is recognizable,  $\times 80$ .

Fig. 2. A slightly later stage,  $\times 80$ .



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- Fig. 3. Still later stage showing the typical apparently tricarpellary condition. *b* represents the placenta arisen out of a fusion of the carpellary margins; *a*, the unfused tip of the carpellary leaf. Note that *b* is nearly twice as broad as *a*,  $\times 80$ .
- Fig. 4. An apparently tetracarpellary gynoeceium of *Gynandropsis pentaphylla*. Note that diagonally placed loculi are of equal size and one set is much bigger than the other,  $\times 54$ .
- Fig. 5. Top portion of the sterile ovary of *Gynandropsis*. The four marginal bundles of the two adjacent carpels, *m*, are clearly seen,  $\times 60$ .
- Fig. 6. The two inrolled carpellary leaves of *Capparis flexuosa* Blume. Each carpel has a midrib bundle and two marginal bundles,  $\times 80$ .
- Fig. 7. The same showing the fusion of the carpellary margins,  $\times 60$ .
- Fig. 8. Transverse section of young ovary of *Cadaba indica*. *f* represents the beginning of the fusion of the two commissural tips,  $\times 120$ .
- Fig. 9. Later stage. The fused portion, *f*, has grown into a septum. Note the prominent commissural bundles from which the ovules are supplied directly,  $\times 70$ .
- Fig. 10. Still later stage. The septum (replum) is complete. *t* is the region of loosely arranged cells in the middle of the replum,  $\times 70$ .



**The Identification of Coniferous Woods by their Microscopic Structure. By  
E. W. J. PHILLIPS, B.Sc., A.R.C.S. (Communicated by Professor V. H.  
BLACKMAN, F.R.S., F.L.S.)**

(With 41 figures in Plates 13, 14 and 15 and 5 in the text.)

[Read 9 May 1940]

MANY keys to the identification of coniferous timbers have already been published, but for one reason or another these all fall short of the requirements of a wood technologist faced with the task of identifying the numerous timber-producing species. Some of these keys are based on material too limited, and fail to take account of the variation shown within the limits of individual species, or deal with material of very young stems or branches, the anatomy of which often differs markedly from that of the adult wood which constitutes the major portion of the trunk. Several of the keys available deal only with very limited numbers of species—for example, the extent of a small collection, the species of one particular geographical region or the members of a single taxonomic group—and are difficult to apply when identification problems are not similarly circumscribed. Moreover, all the published keys are of the dichotomous type, and consequently suffer from the disadvantage that the features of any particular wood have to be examined in a fixed order, although these may not be readily determinable with certainty on the small samples frequently submitted for identification. If a doubtful determination has to be made early in such a key, then even an approximate or group identification is precluded. Another disadvantage of the dichotomous key is that modifications or additions suggested by further experience cannot readily be made.

The primary object in preparing the present key was to provide a comprehensive guide to the identification of those softwood timbers of commercial importance. After careful consideration, it was decided, however, to include in the key not only representatives of the twenty-three genera which have been met with in the course of several years contact with the timber trade, but also representatives of all other genera producing sizeable trees. Descriptive notes on the remaining genera, mainly compiled from the literature, are recorded for reference purposes, but these genera are not included in the key.

In order to overcome the difficulties associated with dichotomous keys a 'multiple entry' key of the type described by Clarke (1938) has been developed, the characters of each species being recorded on cards which have marginal series of perforations (see text-fig. 42) and are adapted for rapid mechanical



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CROSS FIELD PITS														
END-WALLS NODULARIS <input type="radio"/>														
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PRESENT 15 <input type="radio"/>														
CALLITRROID THICKENINGS 12 <input type="radio"/>														
SPIRALS 11 <input type="radio"/>														
TORI SCALLOPED 10 <input type="radio"/>														
PTS X-SERIAL, OPP. 9 <input type="radio"/>														
PITS ALTERNATE 8 <input type="radio"/>														
DIMPLED GRAIN 7 <input type="radio"/>														
GREASY 6 <input type="radio"/>														
DISTINCT TASTE 5 <input type="radio"/>														
DISTINCT ODOUR 4 <input type="radio"/>														
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HEARTWD. COLOURED 2 <input type="radio"/>														
G. RINGS INDISTINCT 1 <input type="radio"/>														
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BOTANICAL FAMILIES														
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PODOCARPACEAE 35 <input type="radio"/>														
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CEPHALOTAXACEAE 37 <input type="radio"/>														
PINACEAE 38 <input type="radio"/>														
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41 <input type="radio"/>														
42 <input type="radio"/>														
GEOGRAPHICAL REGIONS														
EUROPE ETC. 43 <input type="radio"/>														
INDIA ETC. 44 <input type="radio"/>														
MALAYA 45 <input type="radio"/>														
CHINA, JAPAN 46 <input type="radio"/>														
AUSTRALIA 47 <input type="radio"/>														
NEW ZEALAND 48 <input type="radio"/>														
N. AMERICA 49 <input type="radio"/>														
TROP. " 50 <input type="radio"/>														
TEM. S. " 51 <input type="radio"/>														
TROP. AFRICA 52 <input type="radio"/>														
S. AFRICA 53 <input type="radio"/>														
54 <input type="radio"/>														
C <input type="radio"/> B <input type="radio"/> A <input type="radio"/>														

TEXT-FIG. 42.—Specimen card as used in the key.

sorting. A card is prepared for each species, the features being recorded by clipping the card opposite the appropriate holes; on inserting a mounted needle or other suitable appliance into a pack of species cards through any perforation, cards which have been clipped opposite this hole fall out. In dealing with a sample for identification this process is repeated for a succession of characters selected in any order, but with chief regard to the more striking features of the sample.

As a first step in selecting features for use in the key a survey of the literature was made in conjunction with an examination of representative material in the Forest Products Research Laboratory collection. This showed some of the putative diagnostic features to be completely unreliable for identification purposes, others to be of strictly limited application, and still others to require modification before becoming generally applicable. Ultimately thirty-three features were selected; these are defined and explained on pp. 262-269, and a few others of limited value at present are described on pp. 269-278. The geographical origin of a sample is often a valuable clue to its identity and provision is made in the key for using such information.

A key of the multiple entry type does not lend itself to publication in the usual form, and it must be left to the individual investigator to prepare his own set of cards. The data for preparing the present key are given in tabular form on pp. 274-277, from which they may readily be transferred to special cards similar to the one illustrated on p. 260, or merely to a set of plain punched \* cards, a single guide card serving to indicate the holes corresponding to the features listed.

The present work is intended primarily for a wood technologist who has access to a representative wood collection. Consequently detailed descriptions of the timbers, although of considerable value in confirming identifications, are not included. Attention is directed, however, to the notes on the genera (pp. 279-307) in which references are given to literature wherein adequate descriptions of the general characters of the timbers may be found. For a few of the rarer genera, brief descriptive notes have been included, since descriptions or specimens may not be readily available. It must not be overlooked that the tabulated data on pp. 274-277 constitute useful anatomical descriptions.

#### EXPLANATORY NOTES ON THE FEATURES USED IN THE KEY.

In the following notes the features selected as being of value for the purpose of identification are defined, and their significance is discussed. Most of the features refer to the microscopic structure of the wood, but in addition to these certain general features of diagnostic value are included.

It is to be understood that the key is intended primarily for the identification of commercial timber consisting of normal stem wood which has reached a

\* The right to produce this type of card is covered by patents held by the Copeland-Chatterson Co., of Exchange House, Old Change, London, E.C. 4.

fairly adult condition. Wood formed after the first 20-30 years' growth may be regarded as fairly typical of the 'adult' condition. Wood near the pith and small branchwood consists of smaller elements, and often has more resinous tissue and sometimes spiral thickenings, and other features not found in the adult wood. Wood formed during the 'youthful' period can generally be recognized as such (e.g. by the curvature of the growth rings), and due allowance must be made for this and also for any obviously abnormal features in attempting identification ; preferably such material is to be avoided.

Most of the features may be used either in the positive sense or negatively, so that the absence of a certain feature in a particular sample, providing that it appears to be reasonably representative, may safely be regarded as indicating its regular non-occurrence in the species. Some features, however, may only be used positively, and the above assumption cannot safely be made ; this fact is indicated in the following notes under the features concerned.

I. GENERAL. 1. *Growth rings indistinct*. (Fig. 1.) Growth rings are considered indistinct when there is no marked contrast between the final row of latewood tracheids and the succeeding rows of earlywood tracheids as seen in transverse section at magnifications of  $\times 50$  or more. A sample is regarded as having indistinct rings if any rings other than obvious false rings are indefinite, even when the majority are microscopically distinct, e.g., *Juniperus procera*.

Rings which appear distinct macroscopically are frequently indistinct microscopically, e.g. *Podocarpus dactyloides*. Macroscopically indistinct rings are rare in the Coniferae.

Indistinct growth rings are found, with the exception of *Cephalotaxus drupacea*, *Cupressus lusitanica*, and *Tetraclinis articulata*, only in timbers of the tropical and south temperate zones, and except for *Cephalotaxus* are confined to the Araucariaceae, Cupressaceae and Podocarpaceae.

2. *Heartwood\* distinctively coloured* (only to be used positively). This feature refers only to woods possessing a strongly coloured heartwood and not to cases where the heartwood, although distinguishable, merely exhibits a slightly darker shade of the sapwood colour.

As a rule, freshly cut green heartwood does not show its characteristic colour ; this only develops after a period of exposure.

In most instances coloured heartwood is a generic characteristic, heartwood of similar character being formed in all species of a genus. This is well shown in such large genera as *Pinus* and *Larix*. In *Picea* heartwood is lacking throughout the genus, with the partial exception of *P. sitchensis*, which forms a pale heartwood. Notable exceptions occur in Podocarpaceae where some species develop heartwood and others do not. In no single family of Coniferae is heartwood lacking and in no family do all members possess it (except possibly in Taxaceae). It is least strongly developed in Araucariaceae.

\* 'Heartwood' here corresponds to 'Truewood' (sound heartwood) of the Australian literature.

3. *Latewood conspicuous*. (Fig. 2.) Latewood is regarded as conspicuous when dense, sharply defined from the earlywood of the same ring, and of an average width not less than one-quarter the width of the growth ring.

Wide zones of dense wood resulting either from compression wood development or the formation of secondary rings immediately prior to the normal latewood are disregarded.

Conspicuous latewood is a characteristic feature of several of the hard pines and is a useful means of distinguishing sapwood of most species of *Larix* from *Picea*.

4. *Odour pronounced* (only to be used positively). A freshly cut surface of the dry wood should be tested; the odour may often be accentuated by moistening the surface. It is usually much more pronounced in heartwood and is commonly absent from sapwood. In green material the natural odour of the wood is frequently much stronger than in seasoned wood, but is often distinctly rancid. Timber in bulk, as in timber-yard stacks, may have a pronounced odour, e.g. *Pseudotsuga taxifolia*, not detectable in small samples.

Many coniferous woods are characteristically scented, and the only families which appear to lack this property entirely are Araucariaceae and Podocarpaceae. In Pinaceae it is confined to *Pinus* and *Cedrus*, but in Taxodiaceae and Cupressaceae several genera are distinctively scented, e.g. *Chamaecyparis*, *Juniperus* and *Cunninghamia*. As a rule the odour is of the same type throughout the various species of a genus; in some cases all species are similarly scented and in others some lack odour. *Chamaecyparis nootkatensis*, however, has an odour quite distinct from that of the other members of the genus; this wood is exceptional also in structural features. It is interesting that *Chamaecyparis* and *Cupressus*, although doubtfully distinct genera according to some authorities, are differentiated by this property.

5. *Taste* (only to be used positively). The few woods having any definite taste are nearly all scented. Little variety is exhibited, all these woods being slightly bitter or astringent. The bitter taste of *Dacrydium Colensoi* and the astringent taste of *Agathis australis* are of particular value in their identification.

6. *Greasy to the touch* (only to be used positively). Three woods only have been observed to show this feature, viz. *Dacrydium Colensoi*, *Taxodium distichum* and the rare *Callitropsis araucarioides*.

7. *Dimpled grain* (only to be used positively). (Fig. 3.) This feature is due to indentations of the cambium by resin blisters formed in the inner bark and is characteristic of *Pinus contorta* (Record, 1919). It is occasionally present in *P. ponderosa*, *Picea rubra*, *P. sitchensis* and *Larix laricina*. An inconspicuous, minutely dimpled grain is also shown by *Podocarpus spicatus*.

II. TRACHEIDS. 8. *Bordered pits alternate* (Radial walls). (Fig. 4.) This refers solely to the characteristic pitting of the Araucariaceae. A few other woods, e.g. *Cedrus*, have a tendency to an alternate arrangement where the pits are crowded, but these may be distinguished from the Araucariaceae

by the circular outline of the pits and by their larger size. Such cases are disregarded in the key.

9. *Bordered pits multiseriate, opposite* (only to be used positively). (Fig. 5.) This refers to the extensive occurrence of multiseriate pitting throughout the length of the tracheids and not to occasional small groups of opposite pits. This feature is found only in some wide-lumened earlywood tracheids and is not found in wood near the pith.

Pitting of this type is rarely found outside the Taxodiaceae and Pinaceae. It forms a fairly reliable means of distinguishing sapwood of *Larix* from *Picea*.

10. *Margins of tori scalloped*. (Fig. 6 A.) This feature is characteristic of *Cedrus*; marked regular scalloping of the torus margin has not been observed in other genera, although slight irregularity is sometimes shown, e.g. in *Pinus* and *Larix*.

11. *Spiral thickenings present in earlywood*. (Figs. 7 A & 7 B.) This feature is characteristic of only two genera of commercial softwoods, viz., *Pseudotsuga* and *Taxus*; it is also of regular occurrence in *Cephalotaxus*, *Torreya* and in a few non-commercial species of *Picea*. The spirals reported in other tree genera appear to be found commonly in branches, but not in stems of sizeable trees. Occasionally spirals occur near the pith in a number of other species and rarely in more adult wood in *Picea* (Pfurtscheller, 1885) and *Larix*, but in these timbers the thickenings are stouter and are best developed in latewood; in *Pseudotsuga* they are regularly present throughout the earlywood and absent or poorly developed in latewood, and in *Taxus* spirals are present throughout the annual ring. In Cephalotaxaceae and in *Torreya* (Taxaceae) the spirals are commonly in pairs.

It is important to distinguish true spiral thickenings from the spiral cracks which characterize compression wood (Pillow and Luxford, 1937; Phillips, 1937). (See fig. 12.)

12. *Callitroid thickenings*. (Figs. 8 & 9.) These appear typically as pairs of thickening bars across the pit border. They are regularly developed only in the genus *Callitris*, where they have been observed in all species of commercial importance except *C. Macleayana*. Occasional specimens of other woods, e.g. *Juniperus*, show thickenings of a similar character; these, however, are rare and inconspicuous and are disregarded in the key. Such thickenings were observed also in several tracheids in the limited material available of *Actinostrobus acuminatus* and *Pseudolarix*.

III. PARENCHYMA. 13. *Parenchyma present*. (Figs. 10, 17, 23 & 24.) Parenchyma cells in conifers are frequently detectable on account of their dark contents; in longitudinal sections their horizontal walls are characteristic. In species which have sparse parenchyma this is usually located near the outer face of the latewood, and may best be observed in tangential sections passing through the ring boundaries.

Parenchyma associated with resin ducts is disregarded here.

In many Podocarpaceae, Taxodiaceae and Cupressaceae parenchyma forms a prominent feature of the wood ; in Pinaceae parenchyma is never abundant (except in the region of wounds) ; and in Araucariaceae and Taxaceae it is entirely lacking.

14. *Parenchyma abundant* (only to be used positively). (Fig. 24.) The parenchyma occurring in coniferous woods never approaches the quantity to be observed in many hardwoods, and the term 'abundant' is here used with strict reference to conifers only.

Five or more cells per sq. mm. of transverse section in that portion of the growth ring containing most parenchyma is regarded as 'abundant', e.g. *Juniperus virginiana*. In rare cases (e.g. in *Thuja plicata*) parenchyma, although typically absent or sparse, may occur abundantly in an isolated growth ring.

15. *Transverse walls nodular*. (Fig. 23.) The nodular or bead-like thickenings developed on the transverse or end walls of parenchyma cells in several species are generally more conspicuous in tangential sections, where they commonly appear as series of three or more nodules per end wall ; the pits or pit fields are so arranged on these walls that in radial sections the nodules are solitary.

In Cupressaceae, Podocarpaceae and Taxodiaceae this nodular appearance is due to localized thickening of the primary wall (Bailey and Faull, 1934), and is not true pitting in the strict sense, whereas in Abietoideae a similar appearance is produced by true simple pitting of the secondary wall.

The relative size of the nodular thickenings is of value in differentiating genera particularly in the Taxodiaceae (see notes on the family, pp. 296-299).

Of the woods having parenchyma cells with this type of thickening, only certain *Juniperus* species, *Libocedrus decurrens* and members of the Abietoideae have similar thickenings on the end walls of the ray cells (see figs. 15 & 17).

IV. RAYS. 16. *Ray tracheids regularly present*. (Figs. 13, 25, 26, 29 & 30.) In order to distinguish ray tracheids from ordinary parenchymatous marginal cells it is essential, when dentate thickenings of the wall are absent, to observe the fully bordered pit-pairs in sectional view.

Ray tracheids are normally present in all Pinaceae except *Abies*, *Keteleeria* and *Pseudolarix* : in *Abies* they are occasionally present as a result of wounding. Outside the Pinaceae they are normally present only in *Chamaecyparis nootkatensis*. Ray tracheids may also be occasionally found after careful search in most Cupressaceae and in *Sequoia*, but their rare occurrence suffices to distinguish such cases from those in which ray tracheids form a regular feature of the wood.

17. *Ray tracheids dentate*. (Figs. 25, 29 & 30.) Dentate (sometimes partly reticulate) thickenings projecting from the inner face of ray tracheid walls occur in those species of *Pinus* comprising the hard pine group ; small dentate thickenings are regularly present in *Picea*, and are of sporadic occurrence in

*Larix*. They are usually best developed in latewood, and are most conveniently observed in radial sections.

18. *Horizontal walls thin*. (Fig. 14.) This refers to earlywood (radial section), and the walls are regarded as thin if they appear to be thinner than the adjacent vertical tracheid walls above or below the ray. Where the ray-cell wall varies in thickness, the thickest portions only are considered. In certain woods, e.g. *Podocarpus spicatus*, a resinous lining may be present next to the cell wall, and careful scrutiny may be required to distinguish the actual thin cell wall.

Thin horizontal walls are characteristic of the rays of Araucariaceae, Podocarpaceae (except *Podocarpus chilinus*) and a few genera of Cupressaceae; in Pinaceae and Taxodiaceae only *Pinus* and *Sciadopitys* respectively show this feature.

19. *Horizontal walls unpitted*. Examination for this feature is best made on transverse sections (except in cases where ray tracheids obscure most of the ray parenchyma walls), and particularly in the latewood portions of the growth rings, since it is here that pitting is usually best developed (cf. fig. 10).

Unpitted horizontal walls are an important characteristic of all Podocarpaceae (except *Podocarpus chilinus* and *P. dactyloides*), Araucariaceae, some groups of *Pinus* species and certain Cupressaceae and Taxodiaceae.

20. *Horizontal walls strongly pitted*. (Figs. 15 & 18.) This feature is shown by members of the Abietoideae group of Pinaceae, and is best seen in latewood. The pits in this instance are true pits, and not merely primary pit fields as are found in most other families of Coniferae. No instances were observed where the primary pit fields approached in abundance the pits of Abietoideae.

21. *Indentures present*. (Fig. 16.) (Only to be used positively.)

The term 'indenture' coined by Peirce (1936) refers to the depression at the corners of ray cells as seen in radial sections. Indentures appear as pit-like hollows in the horizontal wall in which the ends of the vertical walls stand. Indentures were observed in all families of Coniferae except Araucariaceae. In Podocarpaceae they were found only in *Podocarpus chilinus* and *P. dactyloides*; in Pinaceae they occur throughout the family although not well marked in *Cedrus*, *Keteleeria* and *Pinus*. It is within the Cupressaceae and Taxodiaceae that indentures are most useful in identification. The material examined confirms previous observations that within these families well-defined indentures frequently occur only in *Thuja*, *Thujopsis*, *Cupressus*, *Juniperus*, *Glyptostrobus*, *Taxodium*, *Cryptomeria* and *Cunninghamia*; Peirce (1936) reports them as abundant and conspicuous in *Taiwania*, although they were very rare and inconspicuous in the material available to the present writer. Poorly defined or rare indentures occur in a number of other genera of these families.

Indentures were also observed in *Taxus baccata* and *Torreya nucifera* (Taxaceae), *Cephalotaxus drupacea* (Cephalotaxaceae), and in *Podocarpus chilinus* and *P. dactyloides* (Podocarpaceae).

22. *End walls nodular*. (Figs. 15, 17 & 26.) Nodular or bead-like thickenings, similar to those found on the end walls of parenchyma cells, occur on the

vertical walls of the ray cells (radial section) throughout the Abietoideae section of the Pinaceae and in the soft pine group of *Pinus*. In these species the thickenings correspond with true pitting (Bailey and Faull, 1934); primary pit fields of similar appearance are found also in *Juniperus virginiana* and in *Libocedrus decurrens*, and are included under this feature. (See also remarks on feature No. 15.)

23-27. *Cross-field pitting*. The pits occurring on the areas of contact between ray cells and tracheids (cross-fields) vary from the large, single pits occupying

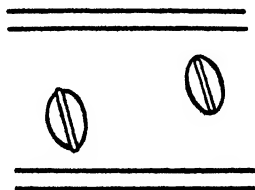


FIG. 43.—Piceoid cross-field pits. Feature 24.  $\times 750$ .

most of the cross-field found in *Pinus* to small bordered pits occupying a very small proportion of the cross-field area, e.g. in *Picea*. The number of pits per cross-field and the relative size of pit border and pit aperture also vary even within the growth ring. At a given position in the growth ring, however, and particularly in the earlywood portion, the majority of the pits conform to one of a number of fairly definite types as described below. (Features 23-27.)

23. *Cross-field pits 1* (-3) large, simple or nearly so, in earlywood. (Figs. 13, 14 & 25). Under this heading are included the window-like pits or primary pit fields found in the *Sylvestris* and *Strobus* groups of *Pinus* and in *Phyllocladus*, *Dacrydium*, *Sciadopitys* and *Podocarpus spicatus*.

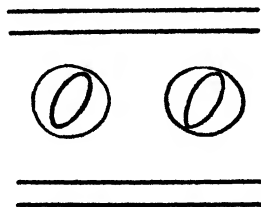


FIG. 44.—Cupressoid cross-field pits. Feature 25.  $\times 750$ .

24. *Cross-field pits piciform*\*. (Fig. 26 and text-fig. 43.) This refers to earlywood pits having narrow and often slightly extended apertures similar to those typically found in *Picea*, *Larix*, *Pseudotsuga* and *Cephalotaxus*. This type of pitting occurs also, usually together with other types, in *Araucaria*

\* The term 'piceoid' is used to denote pits similar to those in the eyes of *Picea* vice 'piciform' first used by Record (1919, p. 75): the terms 'cupressoid', 'taxodioid' and 'pinoid' are similarly derived from the corresponding family and generic names.



*Cunninghamii*, *Cedrus* sp. and *Podocarpus dactyloides*. The slightly extended apertures must not be confused with the slit-like extensions of the pit-apertures found in compression wood of all Conifers.

25. *Cross-field pits cupressoid*. (Fig. 27 and text-fig. 44.) In this type of pitting the apertures in the earlywood are included (contrast piceoid) and are rather narrower than the border. The long axis of the aperture varies in position from vertical to horizontal even within a single specimen.

This type of pitting is characteristic of all members of the Cupressaceae (except *Thuja*) and occurs also in a few Taxodiaceae (*Taiwania* and *Taxodium*), in Araucariaceae, *Podocarpus* spp., *Taxus*, and less regularly in *Cedrus* and *Tsuga*.

The number of cupressoid pits per cross-field is typically small (one, two or four, i.e. two pairs vertically superposed). In Araucariaceae, however, they are usually more numerous and less regularly arranged, and in *Taxodium* they show typical taxodioid arrangement in horizontal rows of three to five pits, except at the ray margins.

26. *Cross-field pits taxodioid*. (Fig. 28 and text-fig. 45.) This refers to earlywood pits having large, ovoid to circular, included apertures wider than the

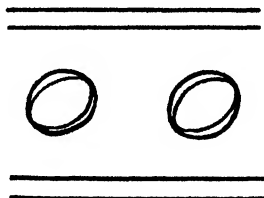


FIG. 45.—Taxodioid cross-field pits. Feature 25.  $\times 750$ .

border. Somewhat similar pits are found in the *Ponderosa* and *Sula* sections of *Pinus*, but these are distinguished by irregularity in shape and size, and the occurrence of extended apertures.

Taxodioid pitting occurs not only in Taxodiaceae, but also in *Abies*, *Cedrus*, many Podocarpaceae and in *Thuja*. In some cases, viz. *Taxodium*, *Podocarpus* spp., and *Cedrus*, cupressoid pits are also normally present.

In certain Taxodiaceae, particularly *Sequoia* and *Taxodium*, the pits are commonly arranged in rows of three to five pits per cross-field except in marginal cells.

27. *Cross-field pits 1-6 pinoid*. (Figs. 29 & 30.) This includes all types of pitting found in *Pinus* except the large window-like type (feature 23). Such pits are fairly small, simple, or with narrow borders, and often of irregular and variable shape. In the *Ponderosa* and *Sula* groups of *Pinus* the pits often resemble the taxodioid type, but differ on account of their variation in size and more pointed apertures.

V. RESIN DUCTS. 28. *Normal vertical resin ducts present* (Figs. 2, 31 and 32) and 29. *Traumatic ducts, vertical or horizontal present* (Figs. 33 and 34) (only to be used positively). Normal vertical ducts are accompanied by normal horizontal ducts in the rays (see feature 30).

Vertical traumatic ducts are characteristically cyst-like and form short tangential series, whereas normal ducts are elongated and usually occur singly. Note that horizontal traumatic ducts (see feature 30) are also included under this heading; these are occasionally present in those Pinaceae having normal horizontal ducts, but are otherwise known to occur only in *Cedrus* spp. and in *Sequoia gigantea*. Such traumatic ducts are distinguishable on account of their large size.

Normal resin ducts are found only in the Pinaceae; traumatic ducts have been reported to occur in all Pinaceae (except *Pseudolarix*) and in *Sequoia* spp. (Bailey and Faull, 1934).

30. *Horizontal resin ducts present (normal and traumatic)*. (Figs. 34, 35, 36 A & 36 B.) Rays carrying horizontal resin ducts are present in all genera having normal vertical ducts with the doubtful exception of *Keteleeria* (see p. 292).

Traumatic ducts are included under this heading as well as under feature 29, since, in small samples, isolated traumatic ducts of small size might be mistaken for normal ducts.

31. *Epithelial cells thick-walled*. (Figs. 32, 35, 36 A & 36 B; cf. 31.) In species having thick-walled epithelial cells, the portion of the epithelium which is presumably secreting resin remains thin-walled; even in sapwood however, many of the cells are thick-walled. Thin-walled epithelium is otherwise found only in *Pinus*, and here the delicate cell walls are generally torn in the process of sectioning.

32 and 33. *Number of epithelial cells per duct*. (Figs. 35, 36 A & 36 B.) This feature is recorded only for those genera having horizontal ducts with thick-walled epithelial cells. The almost invariable mutilation of the thin-walled cells of the pines during sectioning renders counting impracticable; in the few cases observed the number of cells per duct was small, viz. about six.

Six cells or less per duct (as seen in tangential section) is characteristic of *Pseudotsuga*. *Picea* usually has 7 to 9 and *Larix* commonly up to 12 cells and occasionally more (Phillips, 1935). The number of epithelial cells in large traumatic ducts is much larger, e.g. from 30 to 60 cells per duct, and is not taken into account as a diagnostic feature (see fig. 34).

NOTES ON OTHER FEATURES EXAMINED. I. *General: Density*. The marked variation in density within a single species renders this feature unreliable for diagnostic purposes although an extremely low or high density may be suggestive of certain species. The range in average weights of softwoods is much less than in hardwoods; only a few species, viz. *Pinus* spp. (Pitch pines) and *Taxus*, have average densities exceeding 40 lb. per cubic foot in the air-dry condition, and only *Thuja* and some species of *Abies* average less than 25 lb.

The range exhibited by different samples of a single species, however, may exceed the range of average densities for the whole of the Coniferae; *Pinus sylvestris* has been observed to vary from 19 lb. per cubic foot to 56 lb. (B. J. Rendle, 1931). Even woods which show less extensive variation and are characterized by exceptionally high or low average densities are more reliably identified by other characters.

*Crystals present.* (Fig. 18.) Crystals in ray cells have previously been reported in *Abies*, *Cedrus*, *Keteleeria* and *Picea*; the present writer has observed them in normal adult wood of these genera and also in *Pseudolarix*. In these five genera the crystals occur in the form of cubes, octahedra or rectangular prisms, and those in *Abies* and *Picea* are said to consist of calcium oxalate.

Peirce (1934) has reported the occurrence of hexagonal, rarely rectangular prismatic crystals in the vertical tracheids of *Pseudolarix*; those observed by the writer appeared only as cubes or rectangular prisms.

The presence of crystals, which is apparently confined to the Abietoideae, is of such rare occurrence in some of these genera that its inclusion amongst the key features seems unwarranted.

II. *Tracheids*:—*Latewood tracheids thick-walled.* (Fig. 2.) Certain woods, e.g. *Larix* spp., have extremely thick-walled latewood tracheids in which the lumina are correspondingly reduced so that the last few layers of tracheids have their tangential walls thicker than the width of the lumina.

This feature, although quite typical of a few woods, occasionally appears in several others thereby limiting its potential value and rendering it unsuitable for inclusion in this type of key unless a very wide range of material of each species can be examined.

*Tangential walls of latewood pitted.* (Fig. 20 A.) Pits occur on the tangential walls of latewood, and also, in some cases, in the first rows of earlywood tracheids, in all woods showing well-defined growth rings except certain species of *Pinus*. These observations appear to be of physiological significance, but are of little use in identification. The abundant development of these pits in certain members of the Taxodiaceae and their limited occurrence in *Pinus* spp., however, is of some value and is mentioned under the genera concerned.

*Pits eroded.* The peculiar appearance of the bordered pits described by Penhallow (1907) as characteristic of *Chamaecyparis nootkatensis* has been observed by the writer in a number of other species which had been attacked by fungi (e.g. *Stereum sanguinolentum*). The pit borders, membranes and tori become dissolved leaving perfectly regular circular holes in place of the pits. Intermediate stages observed indicate the pathological origin of these eroded pits, and it is concluded that they might be found in any coniferous timber not resistant to this type of fungus.

*Intercellular spaces frequent.* (Fig. 10.) Transverse sections of a few species have been observed to lack the regularly close-fitting rectangular tracheids characteristically found in most Coniferae, the tracheids being slightly rounded

as a whole and consequently giving rise to intercellular spaces or, in some cases, having rounded lumina only. Except for *Juniperus virginiana* the species concerned also possessed poorly defined growth rings.

It was deemed advisable to avoid the general use of this feature as it is readily confused with compression wood which may occur in all species. (See figs. 11 & 12.)

III. *Parenchyma* :—*Parenchyma definitely zonate*. (Fig. 24.) This feature refers to the aggregation of parenchyma cells in limited tangential zones extending for considerable distances tangentially within the growth ring. The individual cells are isolated and never form an extensive tissue like that commonly found in hardwoods.

Lens examination, preferably of a transverse section, is often the best means of observing this arrangement.

Short lines consisting of 3 to 4 cells, as found in certain *Podocarpus* species, are not classed as zonate since they occur throughout the growth ring.

Zonate parenchyma has been found to be of regular or sporadic occurrence in the following genera of Taxodiaceae and Cupressaceae :—*Callitris*, *Chamaecyparis*, *Cryptomeria*, *Cupressus*, *Juniperus*, *Libocedrus*, *Taiwania*, *Taxodium*, *Thuja* (confined to latewood).

Examination of much more material is necessary before the diagnostic value of this apparently variable feature can be reliably estimated. It must be used only positively, if at all.

IV. *Rays* :—*Biseriate rays frequent*. (Fig. 21.) Some degree of biseriation is regularly shown by several species, but extensive biseriation is rare except in the vicinity of wounds. Only in *Sequoia sempervirens* and *Cupressus macrocarpa* have any completely biseriate rays been observed. Peirce (1937) records such rays in *Fitzroya*, *Thujopsis* and *Libocedrus*.

For purposes of record it was decided to note species having one-third or more of the sizeable rays (five cells or more high) partly or completely biseriate. This standard is reached only by the above-mentioned woods.

The variation exhibited by this feature makes it of little value as a positive diagnostic feature : its use is best confined, for the present, to affording corroborative evidence.

*Rays frequently more than 30 cells high*. A record was made of species having more than one ray per millimetre width of tangential section exceeding 30 cells high. Fusiform rays were disregarded ; these are normally considerably higher than ordinary rays.

Tall rays are rare in Coniferae, and only six species were found to fulfil the above conditions, viz. :—*Abies alba*, *Cedrus libani* (in traumatic wood only), *Larix occidentalis*, *Podocarpus gracilior*, *P. usambarensis* and *Sequoia sempervirens*.

According to Peirce (1936, 1937) *Taxodium* may have rays up to 60 cells high and both *Callitris* and *Cupressus* up to 36 cells ; these might require to be included in the above class. Evidently more extensive observations are necessary before this feature can be regarded as of more than auxiliary value.

*Rays rarely more than 15 cells high.* This feature, in common with the preceding one (rays more than 30 cells high), suffers from the drawback that more material than any single investigator is likely to be in a position to examine must be dealt with before a firm diagnostic basis can be achieved. In addition only fully adult wood can be taken into account, since rays in the first 20-30 rings of most species are usually low.

Of the various species which appear to have low rays habitually, this feature is of some diagnostic value in *Athrotaxis* spp., *Chamaecyparis thyoides*, *Cryptomeria*, and *Libocedrus tetragona*.

*Dark cell contents present.* (Fig. 22.) The presence of dark-coloured cell contents in a wood section depends partly on the condition of the wood sample, whether sapwood or heartwood, and partly on the technique used in preparing the section for examination. Gums and true resins are probably mostly extracted by the normal softening treatment with water and the washing in alcohol during sectioning and staining processes. The observations recorded below refer to sections whose contents had survived such treatment. Persistent dark contents in many of the ray cells have been observed (tangential section) in several genera of Cupressaceae and in *Podocarpus* spp. and *Araucaria* spp. In some of these woods no morphological heartwood was present.

Until a complete set of observations has been carried out on samples of heartwood which have been subjected to a more or less standard treatment during preparation, this feature cannot be regularly used in identification.

It has been observed in the following :—*Araucaria Bidwillii*, *A. brasiliana*, *Callitris glauca*, *Cupressus* spp., *Fitzroya cupressoides*, *Juniperus procera*, *J. virginiana*, *Libocedrus Bidwillii*, *L. decurrens* and *L. tetragona*, *Podocarpus ferrugineus*, *P. totara*, *Thuja plicata*, *T. Standishii*, *Saxegothea conspicua*, *Widdringtonia* spp.

*Thickness of end walls.* (Figs. 19 A, 19 B, 20 A, & 20 C.) The thickness of the end walls of the ray cells compared with that of the horizontal walls and also with that of the adjacent tracheids both in earlywood and latewood was examined. These observations indicated that such a feature is unsuitable for general application ; it is, however, useful in distinguishing *Cunninghamia*, which has relatively thick end walls, from *Glyptostrobus*, in which they are particularly thin. In general, species having thin horizontal walls (i.e. distinctly thinner than those of the earlywood tracheids) have end walls of similar thickness ; in the Abietoideae and in *Cunninghamia*, which have thick horizontal walls, the end walls are also of similar thickness : in the remaining Coniferae, which have horizontal walls not distinctly thinner than those of the earlywood tracheids, the end walls are usually one-quarter to one-third the thickness of the horizontal walls.

*Appearance of ray cells.* Ray cells as seen in tangential section normally exhibit a variety of shapes even within a single section. Those near the ray margins are usually more elongated vertically than those near the middle ; tall rays normally have more elongated cells than low rays, and all ray cells

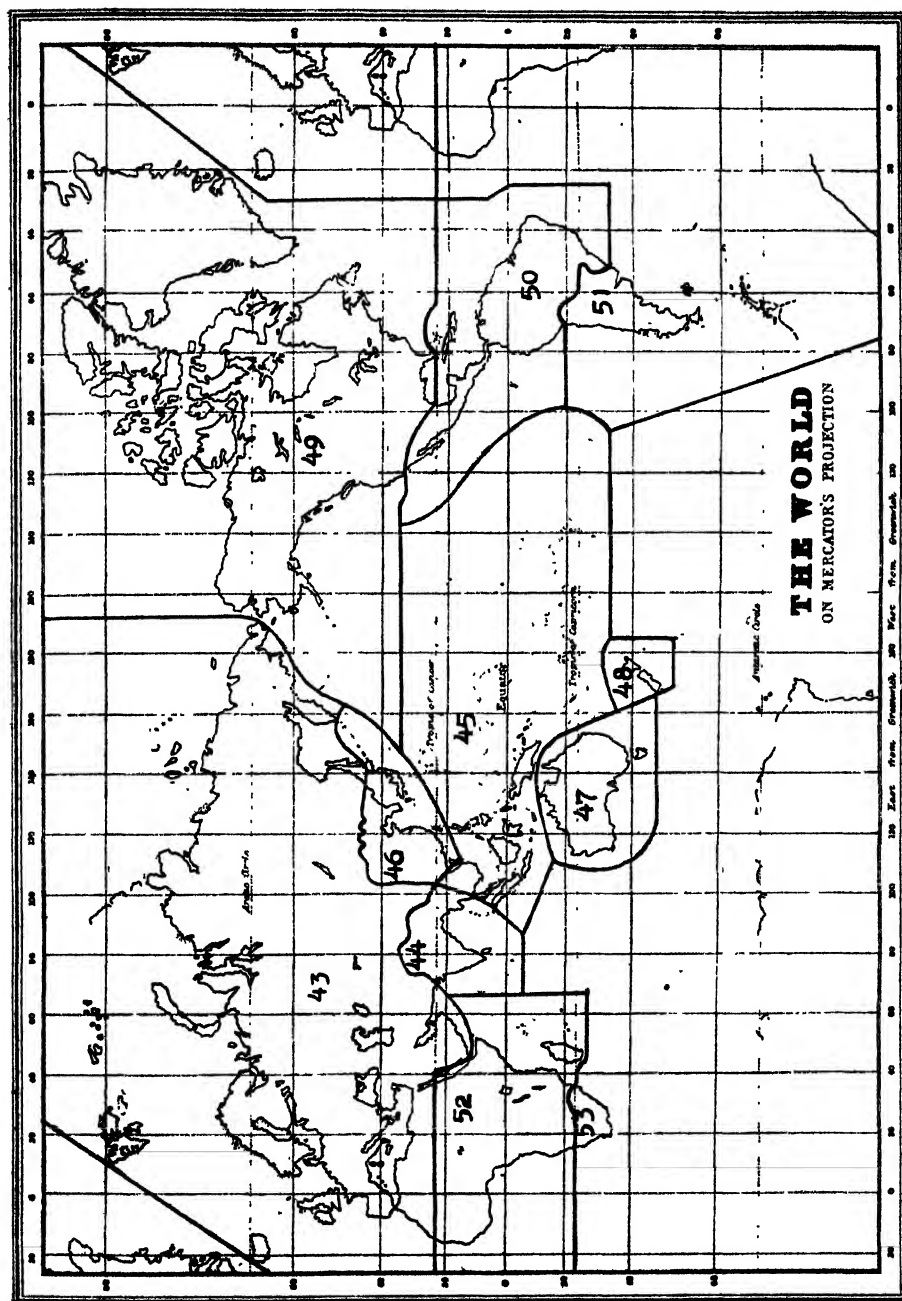


Fig. 46.—Map showing limits of geographical regions.



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TABLE I (continued).

+ = feature present (clipped hole on key card).

- = feature of infrequent or abnormal occurrence (black ink line on edge of key card over unclipped hole).

? = specimens available did not allow a decision to be made (coloured ink line on key card).

\* = data incomplete.

Certain rare species, not taken into account in the methods of separation in the generic notes, are included in brackets.

Species	General.	Tracheids.	Paren- chyma.	Rays.	Cross- field pits.	Resin ducts.	Botanical families.	Geographical regions.
<i>Pinus maritima</i> .....	1 G. Rings indistinct.			16 Ray tracheids.	23 1-3 large.	28 Vertical ducts.	34 Taxaceae.	43 Europe, etc.
<i>P. obovata</i> .....	2 Heartwd. coloured.		13 Present.	17 R.T. dentate.	24 Pileiform.	29 Traumatic ducts.	35 Podocarpaceae.	44 India, etc.
<i>P. rubra</i> .....	3 Latewd. conspicuous.		14 Abundant.	18 Horiz. walls thin.	25 Cupressoid.	30 Horizontal ducts.	36 Araceae.	45 Malaya.
<i>P. sibirica</i> .....	4 Distinct odour.		15 End-walls nodular.	19 " unpitted.	26 Taxodoid.	31 Epith. c. walls thick.	37 Cephalotaxaceae.	46 China, Japan.
<i>Pinus Banksiana</i> .....	5 Distinct taste.			20 " well-pitted walls.	27 1-6 Pnoid.	32 5-8 Epith. cells.	38 Pinaceae.	47 Australia.
<i>P. canariensis</i> .....	6 Grea.			21 Indentures.	28 Taxodoid.	33 7-12 "	39 Taxodiaceae.	48 New Zealand.
<i>P. caribaea</i> .....	7 Dimpled grain.	8 Pits alternate.		22 End-walls nodular.	29 Cupressoid.	34 7-12 "	40 Cupressaceae.	49 N. America.
<i>P. centra</i> .....		9 Pits > 1-seriate, opp.			30 Pileiform.	35 7-12 "		50 Tropical America.
<i>P. contorta</i> var. <i>latifolia</i> ..		10 Torti scalloped.			31 Pileiform.	36 7-12 "		51 Tem. S.
<i>P. echinata</i> .....		11 Spirals.			32 Pileiform.	37 7-12 "		52 Trop. Africa.
<i>P. halepensis</i> .....		12 Cylindroid thickenings.			33 Pileiform.	38 7-12 "		53 South Africa.
<i>P. koraiensis</i> .....					34 Pileiform.	39 7-12 "		
<i>P. Lambertiana</i> .....					35 Pileiform.	40 7-12 "		
<i>P. leucodermis</i> .....					36 Pileiform.	41 7-12 "		
<i>P. monticola</i> .....					37 Pileiform.	42 7-12 "		
<i>P. nigra</i> .....					38 Pileiform.	43 7-12 "		
<i>P. palustris</i> .....					39 Pileiform.	44 7-12 "		



tend to be taller in earlywood than in the denser latewood. In the present connexion the predominant shape of the middle cells of the taller rays in earlywood is considered. This feature is of some value for specific identification within a genus, e.g. *Picea sitchensis* may be distinguished in this way from other *Picea* spp.

The appearance of the ray cells is also influenced by their size and wall thickness. Ray cells are characteristically large in adult wood of *Araucariaceae* and some *Taxodiaceae* and small in *Podocarpaceae*. Very thin walls are also a regular character in this last family, and also in *Araucariaceae* and in *Tetraclinas*. Uniformity, or otherwise, in size of the cells within the ray is another feature to note. Such features are reserved preferably for comparative examination in the late stages of identification.

34-40. BOTANICAL FAMILIES. These are included on the cards for reference purposes. The classification adopted is that of Pilger (1926):—34. *Taxaceae*. 35. *Podocarpaceae*. 36. *Araucariaceae*. 37. *Cephalotaxaceae*. 38. *Pinaceae*. 39. *Taxodiaceae*. 40. *Cupressaceae*.

43-53 GEOGRAPHICAL REGIONS. Caution must be observed in using the origin of a sample as diagnostic evidence since exotic conifers have been very largely employed in afforestation schemes and in certain cases, e.g., *Cupressus macrocarpa* and *Pinus radiata*, species are of far more economic importance outside than inside the limits of their natural distribution.

In preparing this key the appropriate perforation has been clipped only for those regions in which a species is native or fully naturalized. Regions in which a species is known to have been extensively planted (Troup, 1925, and Annual Reports of Forest Departments) are indicated by ink lines on the edge of the card opposite unclipped holes. Growth rings of much greater width than those typical of timber grown in the natural habitat are a common feature of exotic material, and their presence indicates a necessity for caution in using any information about the origin of the sample.

For the purposes of this key the geographical regions are defined as shown below:—

43. Europe, Africa north of Tropic of Cancer, Central and Northern Asia, including Arabia, Afghanistan, Baluchistan, Northern Tibet, Mongolia, Manchuria and Saghalien.
44. India, Ceylon, Burma and Southern Tibet, Andaman, Nicobar, Laccadive and Maldive Islands.
45. Malay Peninsula, Indo-China, Malaysian Islands, Philippine Islands, New Guinea and other islands of Polynesia.
46. China, Japan and Formosa.
47. Australia, including Tasmania.
48. New Zealand and neighbouring islands.
49. North America, including Canada, United States, Greenland and Bermudas.
50. Central America (including Lower California), West Indian Islands, Tropical South America (including Brazil, Paraguay, Bolivia and Peru).

51. Temperate South America, including Chile, Argentine, Uruguay and neighbouring islands.
52. Tropical Africa, Madagascar, Mauritius, Bourbon, Seychelles and neighbouring islands.
53. Africa, south of Tropic of Capricorn.

#### NOTES ON THE FAMILIES AND GENERA OF CONIFERAE.

The following notes summarize the important anatomical features of the various families of Coniferae and also supplement the tabulated data on pp. 274-277 by indicating the distinctive features of each genus and the degree to which genera may be subdivided on anatomical features. Methods of distinguishing individual species of a genus are given here since such specific identification often depends upon characters insufficiently precise for inclusion in the list of key features. Those indicated as diagnostic for the genera and species are given in order of reliability. Where two or more are equally reliable the more readily observed features are given priority.

In the notes on each family Pilger's (1926) classification is followed, including his arrangement of the genera; the succeeding generic notes are arranged, for convenience, in alphabetical order of tree genera followed by shrub genera. Specific names mainly follow the revisions reported by Dallimore (1932); for species not covered by this authority and in the use of the generic names *Arceuthos*, *Chamaecyparis* and *Thujopsis* Pilger is followed.

Literature references dealing with a single genus or small groups of allied genera are noted under each genus; in addition to these special works, there are several publications of a more general character in which information on the majority of the genera may be found. These are marked with an asterisk in the list given on pp. 308-313, and, with certain exceptions, are not quoted under the genera.

**TAXACEAE.** This family consists of three genera, *Taxus* and *Torreya* of the northern hemisphere and the rare monotypic *Austrotaxus* of New Caledonia.

The first two genera agree anatomically in several respects. Both have hard, even-textured woods with well-defined growth rings, fine, rather widely spaced spiral thickenings in the tracheids, and large circular tracheid pits; parenchyma and resin ducts are absent. The rays consist solely of parenchymatous cells having thin smooth end walls, frequent indentures, only moderately pitted horizontal walls and cross-field pits of the cupressoid type.

The micro-anatomy of *Austrotaxus* indicates that this genus is quite distinct from *Taxus* and *Torreya* with which it is grouped by Pilger (1926).

It has also been grouped with *Cephalotaxus* and *Amentotaxus*, which it resembles in having abundant parenchyma, but it differs from these genera in lacking spiral thickenings. According to Dallimore and Jackson (1931) *Austrotaxus* agrees most closely with *Taxus* and *Podocarpus* morphologically; the anatomical data indicate close affinity with *Podocarpus* and refute any relationship with

either Taxaceae or Cephalotaxaceae. In this connection the occurrence of *Austrotaxus* within a zone rich in podocarpaceous species but devoid of members of the other two families appears significant.

**AUSTROTAXUS.** This recently (1922) established genus consists of a single species, *A. spicata*, an evergreen tree of New Caledonia occurring in moist forests on steep slopes at elevations of 1000–3000 ft. It attains a height of 45–80 ft. No description of the wood has been published. According to Pilger (1926) the wood has no resin ducts and the tracheids lack the spiral thickenings found in other members of the Taxaceae. Prince (1938), however, mentions the presence of well-developed spiral thickenings and abundant parenchyma.

The following notes are based on an examination of small twigs. *Growth rings* :—Microscopically indistinct. *Tracheids* :—Fairly regular in arrangement and with squarish or slightly rounded lumina (normal wood, transverse section ; in compression wood the tracheids are rounded and well-marked intercellular spaces are present). Pits on radial walls uniseriate ; spirals or other special thickenings absent except in primary elements (spiral checking of the cell walls was shown, as is usual, in the compression wood present). *Parenchyma* :—Abundant, scattered ; end walls smooth. *Rays* :—1–7 cells high (probably higher in more adult wood), uniseriate ; ray tracheids absent ; cells oval (tangential section), longer vertically ; horizontal walls thin and unpitted ; end walls of similar thickness and also smooth ; indentures absent ; most cross-field pits of the cupressoid type, but taxodioid pits frequent, 1–2 per field except in marginal cells. *Resin ducts* :—Absent.

This examination indicates that *Austrotaxus* differs in several respects from either Taxaceae or Cephalotaxaceae with which it has been putatively allied. From the Taxaceae it is distinguished by its indefinite growth rings (F 1\*), lack of spiral thickenings (F II), presence of abundant parenchyma (F 13 and 14), ray cells with thin, unpitted horizontal walls (F 18 and 19) with no indentures (F 21), and the frequent presence of taxodioid pits (F 26) in addition to those of the cupressoid type (F 25) which predominate. From the Cephalotaxaceae, *Austrotaxus* differs in its lack of spirals (F II), presence of parenchyma with smooth end walls (F 15), and in most of the above-mentioned features of the ray cells (F 18, 19, 25 and 26).

As far as can be judged from the micro-anatomy of this material, *Austrotaxus* is most closely related to *Podocarpus* in which genus it was originally included by Vieillard. The more important features common to both are : ray cells with thin, unpitted horizontal walls (F 18 and 19), abundant scattered parenchyma with smooth end walls (F 14 and 15), cross-field pits varying from the cupressoid to the taxodioid type (F 25 and 26) and also indefinite growth rings (F 1).

**TAXUS.** Pilger (1926) regards the numerous forms of *Taxus* as a single species, *T. baccata*, comprising seven subspecies separated mainly according

to their geographical distribution. On the same basis, other systematists give these closely related forms full specific rank.

*Taxus* is widely distributed in Europe, N. America, E. Asia and Asia Minor ; it is one of the three conifers indigenous in Great Britain. The quantity of timber available is small, but is prized for a number of minor purposes.

Anatomically *Taxus* is readily distinguished from all other conifers of any commercial value by F 28 (lack of resin canals) and F 11 (presence of spiral thickenings)\*. The well-marked heartwood (F 2) differentiates *Taxus* from *Torreya* and *Cephalotaxus* which may be similar microscopically, and from *Pseudolarix*, which is also distinct, on account of the well-pitted horizontal and end walls of its ray cells.

The specimens available indicate that separation of the various forms of *Taxus* from examination of the wood alone is impracticable.

*References* :—Bliss (1918), Pearson and Brown (1932).

**TORREYA.** This genus consists of four rare species all of which attain tree size. The Californian *T. californica* and the Japanese *T. nucifera* furnish timber for occasional local use. The Chinese species *T. grandis* attains a height of 80 feet, but is more often a shrub. The fourth species, *T. taxifolia*, of infrequent occurrence in Florida and Georgia, attains a height of 40 feet.

The wood of all species is distinguished from *Taxus* by its pale yellow heartwood not sharply demarcated from the sapwood, and by its persistent scent ; the ray cross-field pits are typically smaller in *Torreya*. Another difference is the frequent pairing of the spiral thickenings. In the material available this feature was well marked in *Torreya californica* and *T. nucifera*, variable and generally indistinct in *T. taxifolia* and absent in the single specimen of *T. grandis* examined. In radial sections the pairs of spirals usually cross the bordered pits, one strand passing above and the other below the pit aperture. The presence of spirals (F 11) similar in character to those of *Taxus*, the unpitted end walls of the ray cells (F 22) and the presence of well-defined growth rings (F 1) separates *Torreya* from all remaining conifers. Amongst woods having spiral thickenings it is the only one besides *Taxus* without parenchyma (F 13).

*References* :—Fujioka (1913), Kanchira (1926), Record (1934), Tang (1933).

**PODOCARPACEAE.** This large family is best represented in the southern hemisphere and is unique amongst the families of Coniferae in having a large number of tropical species. The following subdivisions are recognized :—

(I) *Pherosphaeroideae*, having a single genus, *Pherosphaera*, which contains no tree species.

(II) *Podocarpoideae*, consisting of *Microcachrys*, *Saxegothea*, *Dacrydium*, *Acropyle* and *Podocarpus*, all of which, except *Microcachrys*, include tree species.

\* ' F ' is used to denote ' feature No. ' ; a bar over the number indicates that the feature is used negatively.

(III) *Phyllocladoideae*. The sole genus, *Phyllocladus*, contains several species attaining tree size.

The *Podocarpaceae* show considerable anatomical diversity even within individual genera. In consequence it is difficult to divide the family into its constituent genera on anatomical grounds. The following features serve to distinguish the family from most other conifers: thin, unpitted horizontal walls (F 18, 19) (except in *Dacrydium intermedium*, *Podocarpus chilinus*, *P. dacrydioides* and *Saxegothea*), absence of alternate tracheid pitting (F 8), special tracheid thickenings of any kind (F 11, 12) and resin ducts (F 28). *Phyllocladus* is distinguished from the tree members of the *Podocarpoideae* by its clearly defined growth rings (F 1), together with large cross-field pits (F 23) and lack of parenchyma (F 13, 14).

**ACMOPYLE.** This genus consists of a single species, *A. Pancheri*, found in abundance near the summit of Mount Mou in New Caledonia. The trees often attain 40–50 ft. in height, but practically nothing is known regarding the timber.

According to Sahni (1921) the wood anatomy agrees with that of *Podocarpus*. Prince (1938) states that the small cross-field pits are simple to semi-bordered with slit-like apertures; wood parenchyma is abundant, but scattered. To judge from the photomicrographs, however, juvenile wood, containing compression wood, was investigated; no adult material is at present available.

An examination of twig material revealed the following additional features: growth rings moderately well defined microscopically; spirals or other special tracheid thickenings absent; wood parenchyma abundant, scattered and with smooth end walls; earlywood cross-field pits large, circular, simple to slightly bordered, 1 per field (commonly 2 in marginal cells).

*References*:—Prince (1938), Sahni (1921).

**DACRYDIUM.** The most important species of *Dacrydium* is 'rimu', *D. cupressinum*, of New Zealand; two or three others are of importance locally (*D. Colensoi*, *D. Franklinii*, *D. intermedium*).

The genus is anatomically heterogeneous, and therefore not readily distinguished as a whole from other conifers; in consequence, however, the individual species are readily differentiated.

*D. cupressinum* is fairly easily recognized by its finely streaked (resin cells) greyish-brown heartwood. Important features for distinguishing it microscopically are: indistinct growth rings (F 1), taxodioid cross-field pitting (F 26) and abundant parenchyma cells (F 14) with smooth transverse walls (F 15). Certain species of *Podocarpus* have a similar combination of features, but these are readily distinguished macroscopically. *D. Colensoi*, another New Zealand timber, is light yellowish-brown in colour, often somewhat greasy to the touch (F 6) and normally of greasy appearance. It has a decidedly bitter taste (F 5): but that of rimu, *D. cupressinum*, is only slightly bitter and *D. Franklinii* and *D. intermedium* are practically tasteless. Microscopically it is distinguished from everything except *Podocarpus spicatus* (see under

*Podocarpus*) by its large cross-field pits (F 23) and lack of both resin ducts and definite growth rings (F 13 and 1).

The Tasmanian species, *D. Franklinii*, is an extremely fine-textured wood with very distinct growth rings. It is light pinkish-brown in colour. Its large cross-field pits (some taxodioid) and abundant parenchyma distinguish it microscopically. Another feature is the peculiar marking of the membranes of the bordered pits (Bailey, 1916) (fig. 6 B).

*Dacrydium intermedium*, a third New Zealand species, is a rather hard, fine- and even-textured wood, similar in general character to *D. Franklinii*. Microscopically it may be distinguished, except from certain *Thuja* species, by its lack of both spiral thickenings and abundant parenchyma (F 11 and F 14), ray cells with moderately well-pitted horizontal walls (F 19) and smooth end walls (F 22), and cupressoid cross-field pits (F 25). The growth rings are distinct but not markedly so, since the latewood tracheids are only slightly thicker-walled than those of the earlywood; this feature contrasts with the condition in *Thuja* species.

*References* :—Garratt (1924), Patton (1927), Penfold (1936).

**PHYLLOCLADUS.** A Tasmanian species, *P. rhomboidalis*, and one New Zealand species, *P. trichomanoides*, yield timber of some local importance.

F 23 (large cross-field pits), F 1 (well-defined growth rings) F 28 and F 14 (lack of both resin ducts and parenchyma) distinguish *Phyllocladus* from other conifers except *Sciadopitys verticillata*. The more rounded shape and larger size of the ray cells as seen in tangential section separates *Sciadopitys*.

The wood of both species of *Phyllocladus* is comparable with yew (*Taxus*) in hardness, but not in colour. No microscopic differences between the species have been observed, and insufficient material is available to determine any consistent macroscopic differences. Specimens available suggest that *P. trichomanoides* is rather coarser in texture than the extremely fine-textured *P. rhomboidalis*.

*References* :—Kanehira (1926), Patton (1927).

**PODOCARPUS.** Several species of this widely distributed genus furnish timbers of high grade, but these are of minor commercial importance outside their country of origin.

Of the numerous African species, *P. latifolius* (Thunb.) R. Br., *P. Henkelii* Stapf and *P. falcatus* (Thunb.) R. Br.\* are important timber trees in South Africa, while the most important of the tropical east African species, *P. gracilior*, is exported from Mombasa, Kenya, to South Africa. The timber of the latter

\* Much confusion exists in the literature concerning the nomenclature of the S. African species of *Podocarpus*. Sim (1921) is at fault in his description of *P. elongata* L'Hér. (pp. 100-1); from the data given he evidently refers to *P. falcatus* R. Br. *P. elongata* L'Hér. is a rarity found in the west of Cape Province. *P. Henkelii* Stapf is described by Sim under the name of *P. falcata*.



species is said not to be differentiated from that of *P. milanjanus*. *P. usambarensis* is at present used only locally in Tanganyika. Various species are of local importance in South America and *P. chilinus* Rich. (= *P. salignus* Don) is said to figure in the German timber market. (Anon. 1938.)

The New Zealand species are probably the best known generally. These include *P. dacrydioides*, *P. totara*, *P. ferrugineus* and *P. spicatus*.

With the exception of *P. chilinus*, *P. dacrydioides* and *P. spicatus*, the genus is characterized by F 28 (resin ducts absent), F 8 (bordered pits not alternate), F 18 and 19 (rays with thin, unpitted horizontal walls), FI 2 (callitroid thickening absent) and F 23 (large cross-field pits lacking). This combination is shared with *Callitris Macleayana*, *Dacrydium cupressinum*, *Tetrachlis articulata*, *Widdringtonia* spp. which can all be distinguished from *Podocarpus* by macroscopic features. Ray tracheids may usually be found after considerable search in those members of the Cupressaceae, but not in *Dacrydium* or *Podocarpus*. *P. spicatus* is separated from all other conifers by F 23 (large cross-field pits), F 1 (indistinct growth rings) and F 2 (orange-brown heartwood). It commonly shows dimpled grain (F 7), but this is less conspicuous than in *Pinus* species, the grain indentations being small and close together. *P. chilinus* is distinguished by FI 8 (rays with thick horizontal walls), FI 15 (parenchyma with smooth cross-walls), and F 1 (growth rings fairly distinct, but often not sharply demarcated); within the genus this species is peculiar in having thick pitted horizontal walls to the ray cells (F 18, 19). *P. dacrydioides* is characterized by F 18, 19 (rays with thin, but pitted horizontal walls), FI 15 (parenchyma with smooth cross-walls) and F 1 (indistinct growth rings); in these respects it agrees only with *Cupressus lusitanica*, which is distinct on account of the abundant dark contents of its ray cells. This is one of the species of *Podocarpus* having typically light-coloured wood; it occasionally shows, however, an irregular sulphur-yellow heartwood; this is sometimes streaked with brown, and according to Hansson (1928) may be light brown throughout.

Of the other members of this genus, *P. ferrugineus* and *P. totara* both have reddish-brown heartwood, and are distinguished from one another by the amount of parenchyma present, the former having at most only sparse parenchyma (cf. *P. spicatus*), whereas in *P. totara* it is abundant. In addition the heartwood is more deeply coloured in the latter species. The remaining *Podocarpus* species are all light-coloured woods which cannot be further separated from one another with any degree of certainty.

*References* :—Battiscombe (1926), Bernath (1937), Brooks and Stiles (1910), Chalk, Burt-Davy et al. (1932, 1935), Crocker (1933), Entrican (nos. 20–22, 1934), F.P.R.L. (1934, 1938), Garratt (1924), Patton (1927), Scott (1927), Sim (1921), Wiesner (1928).

**SAXEGOTHEA.** *Saxegothea conspicua*, the sole representative of this genus, is a rather scarce forest tree of yew-like habit found in Chile and western Patagonia. In Chile it is commonly 30 to 60 ft. high.

No adequate description of the wood has been published. Prince (1938) states that it is a pale pink to chocolate-coloured wood, but Bernath (1937) says it resembles the pale-coloured *Podocarpus* woods; the latter statement may refer to sapwood. A small specimen of adult wood examined by the present writer was greyish-brown in colour resembling *Dacrydium cupressinum* but with less prominent resin cell streaks. The following notes are based on this specimen. *General*:—Some growth rings microscopically indistinct; others moderately clear. Heartwood greyish-brown. Latewood inconspicuous. Odour and taste lacking. *Tracheids*:—Not markedly regular in shape or arrangement (transverse section); pits on radial walls uniseriate, only occasionally biseriate (opposite); spirals or other special thickenings absent. *Parenchyma*:—Abundant in all rings, scattered, and, in addition, forming a distinct zone in the middle of most rings; end walls slightly nodular, difficult to observe on account of the abundant dark cell contents. *Rays*:—Up to 16 cells, mostly 1–9 cells high; uniseriate with only rare partial biseriation; ray tracheids absent; cells oval (tangential section), longer vertically; some variation in cell size within the ray common; horizontal walls similar in thickness to those of the earlywood tracheids and moderately well pitted; end walls approximately one-third the thickness of the horizontal walls and practically smooth; indentures present; earlywood cross-field pits predominantly of the cupressoid type, occasionally piceoid or taxodioid, usually 1 per field except in marginal cells; dark cell contents common. *Resin ducts*:—Absent.

*Saxegothaea* is distinguished from all other conifers by its poorly-defined growth rings (F 1), abundant parenchyma (not exceeded in amount in normal wood of any other conifer) (F 14), ray cells with fairly thick horizontal walls (F 18), lack of spiral thickenings (F 11) and slightly nodular parenchyma cross-walls (F 15). From *Dacrydium cupressinum*, which it superficially resembles, it is readily distinguished by its pitted horizontal ray cell walls (F 19).

*References*:—Bernath (1937), Kanchira (1926), Kräusel (1917), Prince (1938).

The following notes are based on an examination of twigs and on the information available in the literature on those genera of the family which contain only shrubby species.

**MICROCACHRYS.** The only representative of this genus, *M. tetragona*, is a low straggling evergreen bush confined to the summits of the Western Range mountains of Tasmania.

The heartwood is pale brown, rather waxy in appearance and with a mildly resinous scent similar (according to Prince) to citronella; sapwood cream in colour and not sharply demarcated. Growth rings extremely narrow and often not clearly defined microscopically; in the specimen described by Record they were only 3 to 15 cells wide and measured one-fifth to one-tenth of a millimetre in width. Tracheids devoid of special thickenings; uniseriate pitting on radial walls; pits on tangential walls only in latewood: all pit membranes uniformly thickened without tori; resin plates commonly present

opposite rays. Parenchyma normally absent. Rays low, mostly 1 to 5 cells high, maximum 15, the cells in single rows frequently of very irregular form ; horizontal and end walls thin and unpitted ; cross-field pits large, usually 1 per field (2 in marginal cells). Resin ducts absent.

*References* :—Kanehira (1926), Patton (1927), Prince (1938), Record (1935).

**PHEROSPHAERA.** Two species are recognized, *P. Fitzgeraldi*, a low much-branched shrub of the Blue Mountains, New South Wales, and *P. Hookeriana*, a closely branched erect shrub up to seven feet high, restricted to alpine regions of Tasmania. In the anatomy of its stem and other organs and in having root tubercles, *Pherosphaera* agrees with Podocarpaceae, but certain peculiarities in its reproductive structure (Saxton, 1930) support Pilger's view that the genus should be assigned to a distinct subfamily, the Pherosphaeroideae.

Growth rings, clearly defined. Tracheids thick-walled, those of the latewood having their lumina almost obliterated ; in *P. Hookeriana* the tracheids are thinner-walled and more square in cross-section than in *P. Fitzgeraldi* ; pits on radial walls only occasionally partly biseriate ; pits present on tangential walls ; no special wall thickenings. Parenchyma abundant, scattered. Rays low, 1 to 5 cells high, uniseriate : horizontal walls appear to be thin and unpitted ; cross-field pits large, mostly with narrow borders (compare, for example, *Podocarpus ferrugineus*) usually one, rarely two, per cross-field. Resin ducts absent.

*References* :—Groom (1916), Kanehira (1926 ; but note his fig. 47 for *P. Hookeriana* appears to be incorrectly labelled), Patton (1927), Prince (1938), Saxton (1930).

**ARAUCARIACEAE.** The Araucariaceae, comprising the two genera *Agathis* and *Araucaria*, has a distribution chiefly confined to the southern hemisphere.

Anatomically this family is readily distinguished from all others by the characteristic alternate tracheid pitting. The Araucariaceae are also peculiar in lacking crassulae (bars of Sanio). The two constituent genera are of such similar structure that differentiation on microscopical features is not always possible.

**AGATHIS and ARAUCARIA.** These two genera are distinguished from all others by the alternate arrangement of the small bordered pits on the tracheid walls (F 8), but do not appear separable from one another on any positive anatomical features. *Araucaria*, however, furnishes mostly whitish or very light-coloured woods (irregular red streaks in *A. brasiliana*), whereas species of *Agathis* form brownish heartwood. Leaf traces occur in the timbers of both genera, but while these are extremely rare in *Agathis* they are usually present and are often quite numerous in specimens of *Araucaria*. Four-seriate arrangement of the tracheid pits appears to be shown only by *Agathis* and this infrequently ; most samples of both genera show 2- or 3-seriate pits.

**AGATHIS.** In practice the commonest problem is to distinguish between *A. australis* and other species of less repute. The principal sources of commercial timber are :

- (1) New Zealand kauri—*Agathis australis*.
- (2) Australian kauri—Chiefly *A. Palmerstonii* together with small quantities of *A. microstachys* and *A. robusta*.
- (3) Fijian kauri—*A. vitiensis*.
- (4) Vanikoro kauri—*A. macrophylla*.

The features set forth in the table on p. 288 are of value in distinguishing these timbers.

**ARAUCARIA.** Three species of *Araucaria* are of commercial importance, viz., *A. brasiliana* from South America and *A. Bidwillii* and *A. Cunninghamii* from Australia.

The South American species is distinguished by the irregular red markings present in its heartwood ; *A. Bidwillii* sometimes shows a pinkish-brown heartwood, while no heartwood coloration has been reported for *A. Cunninghamii*. The Australian species are separable, according to Cohen (1933), by the following chemical test.

5 g. of powdered air-dry wood are refluxed for 2-3 hours with 50 c.cm. water, at about 100° C. The resulting liquor is filtered, the residual wood pressed and washed over the filter with a further 50 c.cm. water and the total extract made up to 100 c.cm. To 2 c.cm. of extract, in a large test tube 1 c.cm. of concentrated sulphuric acid is added to form a layer. The layers are mixed by gentle shaking. *A. Bidwillii* gives a pink colour immediately followed by the formation of an orange precipitate. *A. Cunninghamii* gives no immediate colour change and later forms a white precipitate.

**References** :—Cohen (1933), Dadswell & Langlands (1933), Entrican (No. 26, 1935), Francis (1928), Kleeberg (1885), Patton (1927), Phillips (May, 1935), Pool (1929), Seward & Ford (1906), Thiselton-Dyer (1901), R. B. Thompson (1913), Welch (1927).

**CEPHALOTAXACEAE.** A small family confined to eastern Asia and consisting of *Cephalotaxus*, a genus of small trees and shrubs and the shrubby monotype *Amentotaxus argotaenia*.

The important anatomical features distinguishing members of this family are : indistinct growth rings (F 1), spiral thickenings in tracheids (F 11) (commonly grouped in pairs and often similar in appearance to callitroid thickenings), parenchyma with nodular end-walls (F 15) and fairly thick horizontal ray-cell walls (F 18).

**CEPHALOTAXUS.** Of the five species of this genus, four attain tree size and yield small timber of limited local use. *C. drupacea* of Central China and Japan, and *C. Fortunei*, found throughout the southern half of China, appear to be

TABLE II.—Features for the separation of *Agathis* species.

Species.	Density lb./c. ft. (air-dry).	Taste.	Tracheid plugs in heartwood.	Extract+alkali*.	Extract+ferric chloride.
1. <i>A. australis</i> .....	36-44 (Average c. 40).	Astringent.	Numerous.	Clear bright yellow.	Greenish-yellow.
2. <i>A. Palmerstonii</i> .....	20-36 (Average c. 30).	Only slightly astringent.	Normally absent.	Only pale yellow.	Brown.
3. <i>A. titensis</i> .....	31-37 (Average c. 34).	Tasteless.	Numerous.	Pale yellow or bright yellow.	No reaction.
4. <i>A. macrophylla</i> .....	29-38	Tasteless.	Numerous.	Colourless or pale yellow.	No reaction.

\* The procedure is to boil 1 g. of small chips for 1 minute in 20 c.cm. water, filter and add one drop of dilute caustic soda or potash (cf. Welch, 1927).

the most widely distributed. The remaining species, *C. Griffithii* and *C. Mannii*, are confined to mountainous regions of Assam.

*C. drupacea* (the only species of which adult material has been examined) is distinguished from other conifers by F 1 (absence of microscopically distinct growth rings) and F 11 (the presence of spiral tracheid thickenings). Differences in the character of the spiral thickenings may serve to distinguish *C. drupacea* and *C. Fortunei*, but insufficient material is available to determine the significance of differences noted. The spirals are often in pairs, but this is not as consistently shown as in *Amentotaxus*. Both woods lack distinct heartwood, and are of a yellowish-white to brownish-yellow colour throughout. They rank among the harder softwoods.

*References* :—Fujioka (1913), Tang (1933).

**AMENTOTAXUS.** *A. argotaenia* is an evergreen bush, 6–10 feet high, found in Hong Kong, Formosa and Western China.

The wood is hard and moderately heavy for a softwood, about 36 lb. per cubic foot air dry, yellowish to reddish brown in colour, but without distinct heartwood. Growth rings generally narrow and microscopically indistinct. Tracheids somewhat rounded in cross-section in earlywood with uniseriate pitting and rather widely spaced spiral thickenings arranged in pairs. Parenchyma cells commonly wider than the tracheids, abundant and scattered with nodular end walls. Rays up to 10 cells high, the cells commonly having dark contents; horizontal walls relatively thick, sparsely pitted; end walls smooth; cross-field pits of the piceoid or cupressoid type, 1 to 4 per cross-field. Resin ducts absent.

*References* :—Kanehira (1926), Prince (1938), Tang (1933).

**PINACEAE.** This is the largest and economically most important family of Coniferae. With the exception of *Pinus*, which extends into the tropics (usually at high altitudes), the family is confined to the temperate regions of the northern hemisphere.

Two subdivisions which are quite distinct anatomically are recognized as follows :

(I) Abietoideae, which includes *Abies*, *Keteleeria*, *Pseudotsuga*, *Tsuga*, *Picea*, *Pseudolarix*, *Larix* and *Cedrus*.

(II) Pinoideae, which consists of a single genus *Pinus*.

All nine genera are composed mainly of species attaining tree size.

Throughout the family well-defined growth rings (F 1) and sparse or no vertical parenchyma (F 14) are characteristic. Features found only in the Pinaceae include normal resin ducts (F 28, 30), well-pitted horizontal ray-cell walls (F 20), dentate ray tracheids (F 17) (consistently developed ray tracheids with smooth walls are found outside this family only in *Chamaecyparis nootkatensis*), scalloped tori (F 10) and conspicuous latewood (F 3).

*Pinus* differs from the genera of the Abietoideae in the character of its cross-field pitting (F 23 or F 27); and in having resin ducts with thin-walled epithelial cells; it may also be distinguished by combinations of the following features :

reddish-brown heartwood present (F 2), tori not scalloped (F 10), spirals absent (F 11), parenchyma absent (F 13), ray tracheids, smooth or dentate, present (F 16 and 17).

The other genera may be separated from each other fairly readily, except perhaps *Abies* and the rare *Pseudolarix*. The features of value for this purpose are tabulated opposite (Table III):—

**ABIES.** Some forty species of *Abies* are recognized all of which attain tree size and many furnish commercial timber. Two species are common on the United Kingdom market, viz., the European *A. alba* and the North American *A. balsamea*.

Woods of this genus may be recognized by the following combination of features : F 22 (vertical end walls of ray cells strongly pitted), F 26 (majority of cross-field pits small, but of the taxodioid type), F 10 (margins of tori not scalloped), F 28 (normal vertical resin ducts absent). Microscopically *Abies* closely resembles the rare genus *Pseudolarix*.

Crystals of calcium oxalate are often present in the ray cells in this genus, but crystals are of sporadic occurrence also in a number of other genera, viz., *Cedrus*, *Picea* and the relatively rare genera *Keteleeria* and *Pseudolarix*. Ray tracheids are sometimes found in *A. balsamea*, but are usually associated with wounds ; vertical resin canals of traumatic type are also of occasional occurrence in the genus.

Identification of the individual species does not appear practicable, but a subdivision of the American species into two groups based on colour of heartwood and on density has been suggested by Record (1934). *A. alba* and *A. balsamea* both belong to the group characterized by pale-coloured heartwood and relatively low density. Examples of the other group which are denser and have yellowish-brown heartwood, with a reddish tinge are *A. nobilis*, *A. magnifica* and *A. Pindrow*.

*References* :—Dippel (1863), Holden (1913), Kny (1910), Record (1934), W. P. Thompson (1912), Wiesehuegel (1932).

**CEDRUS.** Four geographical forms of a single species of *Cedrus* are recognized and for horticultural convenience are given the specific names, *C. brevifolia*, *C. atlantica*, *C. Deodara* and *C. libani*.

The last three are commonly grown in Great Britain, and are occasionally found in home-grown timber merchants' stocks. The deodar (*C. Deodara*) is of considerable importance in India, while in the Mediterranean region *C. atlantica* is locally important.

The woods of these species are very similar in character and their separation does not appear practicable. The sweet pungent odour (F 4) which is given off only by the heartwood, is peculiar to this genus, and so is the well-marked scalloping of the tori of the bordered pits (F 10). The occasional traumatic resin ducts in the rays are found outside this genus only in *Sequoia*.

*References* :—Barghoorn & Bailey (1938), Campredon (1934), Chrysler (1915).

TABLE III.—Features for the separation of the Abietoideae.

	Heartwood coloured (F 2).	Latewood conspicuous (F 3).	Tracheid pits > 1-seriate (F 9).	Tori scalloped (F 10).	Tracheid spirals (F 11).	Normal ray tracheids (F 16).	Normal vertical ducts (F 28).	Horizontal resin ducts (F 30).	Epithelial cells (5-6)   (7-12) (F 32). (F 33).
<i>Abies</i> .....	-	-	±	-	-	-	-	-	-
<i>Keteleeria</i> .....	-	+	+	-	-	-	+	-	-
<i>Pseudotsuga</i> .....	+	+	+	-	+	+	+	+	+
<i>Tsuga</i> .....	-	-	+	-	-	+	-	-	-
<i>Picea</i> .....	-	-	-	-	-	+	+	+	+
<i>Pseudolarix</i> .....	-	-	+	-	-	-	-	-	-
<i>Larix</i> .....	±	+	+	-	-	+	+	+	+
<i>Cedrus</i> .....	±	-	-	+	-	+	-	*	-

\* Traumatic ducts only.



**KETELEERIA.** Six species of this genus are recognized (Flous, 1936), of which only *K. Davidiana* appears to occur in any appreciable quantity. This species is found in the central, western and south-western provinces of China and also in Formosa.

Microscopically the wood is readily distinguished except from *Abies* and *Pseudolarix*, by F 20 (rays with well-pitted horizontal walls) F 10 (tori not scalloped), F 16 and F 30 (horizontal resin ducts and regular ray tracheids absent) and from these genera by F 3 (wide dense latewood zones) and F 28 and F 29 (frequent presence of resin ducts). These ducts are mentioned by Kanehira (1926) and are present in specimens F.P.R.L. 3016 and 11201, and I.F.I. 2548 (in which many are of traumatic type) and also in *K. Fortunei*, F.P.R.L. 9769, but absent in Tang's specimen.

The frequent fusion of pairs of tracheid pits is an uncommon feature found in this wood.

*References.*—Flous (1936), Kanehira (1926), Tang (1933).

**LARIX.** Species of commercial importance include *Larix decidua*, *L. Kaempferi*, *L. laricina*, *L. occidentalis* and *L. sibirica*, and possibly *L. Gmelini* (= *L. dahurica*). The specific identity of Russian and Siberian larch is not certain, but to judge from the geographical distributions timber shipped from Vladivostok probably includes *L. Gmelini* and perhaps some *L. sibirica*, while that from Northern Russia is mainly *L. sibirica* with some *L. decidua*.

Of the Old World species, the European *L. decidua* occurs as far east as 65° E. *L. sibirica* is found from about 40° E. to 110° E., and *L. Gmelini* from 110° E. to the coast and also in Japan. The Japanese *L. Kaempferi* has been planted in many parts of Europe; the bulk of the timber so produced is relatively coarse-textured and lighter in weight than the indigenous species.

*Larix* is readily separated from all other genera except *Picea* on anatomical features, e.g. F 30 and 33 (horizontal resin ducts present with more than six epithelial cells). The dense, well-defined latewood bands and coloured heartwood, and the generally higher number of epithelial cells per horizontal resin duct (Phillips, May 1935) are the best features for distinguishing *Larix* from *Picea*. The infrequent occurrence of minute dentate thickenings on the internal surface of the ray tracheid walls and the frequent presence of biseriate tracheid pits are other features of value in certain cases. In *Picea* dentations are usually present and the tracheid pits are only rarely biseriate.

Satisfactory separation of the various species does not appear to be practicable, particularly when only small samples are available for examination. Of the two American larches, the pale yellowish-brown heartwood and coarser appearance of *L. laricina* usually distinguishes it from *L. occidentalis*, which is commonly fine in texture and has a reddish-brown heartwood.

*References* :—Brem (1934), Chowdhury (1931), Johnson and Bradner (1932), Ostenfeld and Larsen (1930).

**PICEA.** Seven species yield timber of prime commercial importance, viz., the eastern North American *P. glauca*, *P. mariana* and *P. rubra* which are sold, often mixed with some *Abies balsamea*, as White spruce, the western North American *P. Engelmannii*, and *P. sitchensis*, the European *P. Abies*, and eastern European and Asiatic *P. obovata*.

*Picea*, as represented by commercial species, is distinct microscopically from all woods except *Larix* on account of F 24 (piceoid cross-field pitting), and F 30 and F 33 (presence of horizontal resin ducts typically with more than six epithelial cells). The characteristically narrow and poorly defined late-wood zones and the absence of deeply coloured heartwood serve to separate *Picea* from *Larix*. The more frequent occurrence of minute dentations on the internal surface of the ray tracheid walls in *Picea* is another feature often useful as corroborative evidence.

The various spruce timbers are not definitely distinguishable, except *P. sitchensis*, which differs from the remainder in having round to squarish ray cells as seen in tangential sections and in having a distinct pinkish-coloured heartwood.

**References :—**Brem (1934), Erdtmann (1933), Fujioka (1913), Pfurtscheller (1885), Phillips (1933, 1934, July 1935), Peirce (1934), Tang (1933).

**PINUS.** This genus comprises some 80 species, of which rather less than half yield timber of commercial importance. The bulk of the pine timber on the United Kingdom market is furnished by a dozen or so species. These include the white or soft pines, *P. Strobus*, *P. monticola* and *P. koraiensis*; the pitch pines, *P. palustris*, *P. Taeda*, *P. echinata* and *P. caribaea*; and also *P. ponderosa* and *P. Pinaster*, *P. sylvestris* and *P. resinosa*.

The genus is readily distinguished from all other Coniferae by F 28 and F 31 (presence of resin ducts with thin-walled epithelial cells). On the presence of smooth or dentate ray tracheids subdivision of the genus may be made into the soft pine and hard pine groups: these correspond with the botanical subgenera *Haploxyylon* and *Diploxyylon*. Specific identification is not generally possible unless the geographical origin of the material is known, but detailed microscopic examination will usually permit of a specimen being classified under one of the following seven groups recognized by Rol (1932) :—

1. *Strobus*. Ray tracheids with smooth walls (F 17); cross-field pits 1–3 large (F 23), tangential wall pits on latewood tracheids numerous, e.g. *P. Strobus*, also *P. Cembra*, *P. koraiensis*, *P. Lambertiana*, *P. monticola*.

2. *Parrya*. Ray tracheids with smooth walls (F 17); small cross-field pits 2–4 piceoid to pinoid (F 27); tangential wall pits on latewood tracheids numerous, e.g. *P. Gerardiana*. (No commercially important species.)

3. *Sula*. Ray tracheids inconspicuously dentate (F 17); cross-field pits 1–4 pinoid (F 27); tangential wall pits absent, e.g. *P. halepensis*, also *P. canariensis*, *P. leucodermis*, *P. longifolia*.

4. *Ponderosa*. Ray tracheids dentate (F 17) ; cross-field pits 1-4 pinoid (F 27) ; tangential wall pits absent, e.g. *P. ponderosa* also *P. contorta*, *P. patula*, *P. Pinaster*, *P. radiata*.

5. *Taeda*. Ray tracheids dentate and reticulate (F 17) ; cross-field pits 3-6 pinoid (F 27) ; tangential wall pits sparse, e.g. *P. palustris*, also *P. Banksiana*, *P. caribaea*, *P. echinata*, *P. Taeda*.

6. *Khasya*. Ray tracheids inconspicuously dentate (F 17) ; cross-field pits 1-2 large (F 23) ; tangential wall pits absent, e.g. *P. khasya* (no commercially important species).

7. *Sylvestris*. Ray tracheids dentate (F 17) ; cross-field pits 1-2 large (F 23) ; tangential wall pits rare, e.g. *P. sylvestris*, also *P. densiflora*, *P. nigra*, *P. resinosa*.

Within some of these groups further distinctions can be made on the basis of certain variable features such as the size of resin ducts ; until this variation has been exhaustively studied, however, the formulation of rules for more positive identification is inadvisable.

It may be noted that within the pitch pine group (*Taeda*) consistently irregular growth rings having multiple bands of latewood have been observed to occur only in *P. caribaea*.

*References* :—Bailey (1909, 1910), Bitting (1908), Chang (1936), Djaparidze and Wassilewskaja (1934), Forest Products Research Laboratory (1937), Fujioka (1913), Garratt and Fahnestock (1938), Groom (1913), Jaccard and Frey-Wyssling (1935), Kanehira (1926), Kienholz (1931), Mohr and Roth (1896), Record and Kuylen (1926), Rendle (1930, Dec. 1931), Rol (1932), Shaw (1914), Tang (1933), Tubeuf (1916), U.S.D.A. (Techn. note 141, 1937, 214, 1936, 215, undated), Welch (1927).

**PSEUDOLARIX.** The sole species of this genus, *P. amabilis* (syn. *P. Fortunei* and *P. Kaempferi*), attains a height of 130 ft. and 8 ft. in girth, but appears to be of too limited occurrence for commercial exploitation. It is found only in parts of the south-eastern provinces of China (Price, 1931).

The wood is described as light in weight about 27 lb. per cu. ft., air-dry (Tang, 1933), with a yellowish-brown heartwood not markedly distinct from the cream-coloured sapwood (Peirce, 1934 ; Prince, 1938 ; Tang, 1933) ; microscopically it may be distinguished from all conifers except *Abies* by F 22 (vertical end walls of ray cells strongly pitted), F 26 (taxodioid cross-field pits), F 10 (margins of tori not scalloped), F 28 (normal vertical resin ducts absent). The following features, observed in the single specimen available, may serve to differentiate *Pseudolarix* from *Abies*. Firstly, the presence of rather small calcium oxalate crystals. These, instead of occurring more or less scattered in normal marginal ray cells as in *Abies*, are found closely packed and completely filling enlarged isolated marginal ray cells, usually near ring boundaries ; crystals have also been reported in the latewood tracheids (Peirce, 1934) and in the present specimen crystals were observed in the tips of a few earlywood

tracheids, and in occasional short tracheids of irregular shape. Secondly, pairs of feebly developed thickenings are commonly present associated with the apertures of the latewood tracheid pits; in tangential sections these thickenings in some cases resemble the bars found in *Callitris* (see fig. 9). The pitting of the horizontal walls of the ray cells, although well developed in low rays, is generally less marked in the larger rays in comparison with *Abies*. *Pseudolarix* also appears to differ in not responding to wound stimulation. Traumatic resin ducts are rare and ray tracheids have never been observed (Holden, 1913; Peirce, 1934).

Spiral thickenings have been reported in latewood tracheids (Peirce, 1934; Tang, 1933), but from the descriptions given it is evident that compression wood was examined; the spiral checking typical of this abnormal tissue is to be found occasionally in all conifers (see p. 264). Compression wood also occurred in the present material, but in the normal wood spirals were absent.

*References* :—Holden (1913), Peirce (1934), Price (1931), Prince (1938), Tang (1933).

**PSEUDOTSUGA.** The only species of commercial importance is the North American Douglas fir, *P. taxifolia*. Two types of this timber are sometimes recognized, viz. 'yellow fir' and 'red fir', and the origin of these different types is a subject of frequent confusion. Actually the 'yellow fir' is the lighter-coloured wood of finer and more even texture obtained from slowly grown trees or the outer portions (but not necessarily sapwood) of old trees, and 'red fir' is the deep reddish, coarse-textured wood from nearer the centre of trees. Timber from the coast region is largely of the 'yellow fir' type while much of that from trees grown in the mountain and inter-mountain region is of the 'red fir' type.

It may be noted that in American-grown material the resin ducts commonly occur in pairs or larger groups, while in timber grown in Great Britain the ducts normally occur singly.

*Pseudotsuga taxifolia* is easily recognized microscopically by F 30 together with F 32 (presence of horizontal resin ducts with few epithelial cells) or F 11 (spiral thickenings in the tracheids): these thickenings are best developed in the earlywood, whereas in *Larix* and *Picea*, where spirals are of sporadic occurrence, they are best developed in the latewood.

*References* :—Record (1934), B. J. Rendle (Aug. 1931), U.S.D.A. Techn. note 198 (1936).

**TSUGA.**—Two species of this genus produce timber of commercial importance, viz., the North American *T. heterophylla* and *T. canadensis*. Other species, however, yield timber for local use, of which the following may be of future interest, *T. chinensis* and *T. yunnanensis* (China) and *T. diversifolia* and *T. Sieboldii* (Japan).

*Tsuga* is distinguished from other conifers, except *Chamaecyparis nootkatensis* and *Cedrus*, microscopically by F 16 (regular presence of ray tracheids)

and F 28 (absence of normal resin canals). F 15 (nodular thickenings on the transverse walls of the parenchyma) differentiates *Tsuga* from *Chamaecyparis nootkatensis* and F 10 torus scalloping absent separates it from *Cedrus*.

It may be noted that irregularly arranged thickening bars on the pit membrane radiating from the torus are commonly present in *Tsuga*. (*Tsuga* may also be distinguished from these timbers by its pinkish-brown colour, relatively wide latewood bands and lack of distinctive odour.)

*Tsuga canadensis* is best separated from *T. heterophylla* by the consistently more pronounced contrast between earlywood and latewood shown by the former species.

*References* :—Fujioka (1913), Kanehira (1926), Tang (1933).

**TAXODIACEAE.** Of the eight small genera composing this family seven have limited distributions in the northern hemisphere ; the eighth, *Athrotaxis*, occurs in Tasmania. The family contains only thirteen species, all of which attain tree size.

The following are characteristic features of *Taxodiaceae* ; clearly defined growth rings (F 1), no alternate tracheid pitting (F 8), abundant parenchyma (but absent in *Sciadopitys*), thickened horizontal ray cell walls (F 18) (except in *Sciadopitys*), frequent presence of indentures (F 21) (except in *Sciadopitys*, *Athrotaxis* and *Sequoia*), smooth end walls of ray cells (F 22), taxodioid ray cross-field pitting (F 26) (except in *Sciadopitys*, *Taxodium* and *Taiwania*) and absence of normal resin ducts (F 28) (occasional vertical and horizontal traumatic ducts in *Sequoia*).

The family is subdivided as follows :—

(I) *Sciadopityoideae* :—*Sciadopitys*.

(II) *Taxodioideae* :—*Sequoia*, *Taxodium*, *Glyptostrobus*, *Cryptomeria*, *Athrotaxis*, *Taiwania* and *Cunninghamia*.

These two subfamilies are quite distinct anatomically since *Sciadopitys* lacks parenchyma (F 13, F 14), has thin-walled horizontal ray-cell walls (F 18) and large cross-field pits (F 23), features shown by none of the *Taxodioideae*.

*Taiwania*, on account of its cupressoid cross-field pits (F 25) and the typically smooth horizontal walls of its parenchyma (F 15) (only very rarely slightly nodular) is distinct from the remaining genera of the *Taxodioideae* section which call for close examination of the details indicated in the following generic notes for their individual separation.

**ATHROTAXIS.** The genus consists of three closely related species confined to Tasmania. *Athrotaxis selaginoides* appears to be the only species capable of yielding an appreciable quantity of timber, and this is of little more than local importance.

*Athrotaxis* and the other members of the *Taxodiaceae* are separated from the remaining conifers by F 26 (taxodioid cross-field pits), F 14 and 15 (abundant

parenchyma not confined to latewood ; nodular end walls) and F 18 (thick-walled ray cells).

Low rays, rarely exceeding 10 cells in height in adult wood, prominent thickening at the corners of the relatively small ray cells (tangential section), the numerous pits on the tangential walls of the tracheids and the relatively inconspicuous cross-wall pitting of the parenchyma distinguish *Athrotaxis selaginoides* from other members of the Taxodiaceae. (Cf. notes under *Cryptomeria*, *Cunninghamia*, *Glyptostrobus*, *Sequoia*, *Taxodium* and *Thuja*.)

References :—Patton (1927), Peirce (1936).

**CRYPTOMERIA.** The single species of this genus, *C. japonica*, is of considerable importance in the Far East, and has been largely used for afforestation in Japan (Fujioka 1933).

It is one of the few light-weight coniferous timbers which form a dark reddish-brown heartwood (cf. *Cunninghamia lanceolata*, *Libocedrus Bidwillii*, *Sequoia sempervirens*, *Thuja plicata* and *T. Sieboldii*).

Anatomically it is readily distinguished from these species by the fairly conspicuous pitting regularly present on the cross-walls of the abundant parenchyma cells which are not confined to the latewood (contrast *Thuja*). Features 26, 14 and 15 (taxodioid cross-field pits and abundant parenchyma with nodular cross-walls) distinguish it from all conifers except certain other Taxodiaceae and *Thujopsis*. From the latter it is separated by its relatively large cross-field pits while the conspicuous nodules on the parenchyma cross-walls, typically oval ray cells (tangential section), rather low rays (mostly under ten cells high) and only moderately abundant pits on the tangential walls of the tracheids distinguish it from other Taxodiaceae (cf. notes under *Athrotaxis*, *Cunninghamia*, *Glyptostrobus*, *Sequoia* and *Taxodium*).

References :—Fujioka (1913 and 1933), Fujioka and Takahashi (1921), Peirce (1936), Tang (1933).

**CUNNINGHAMIA.** Both species of this genus attain tree size. *C. lanceolata* is one of the most important coniferous timbers in China; *C. Konishii*, a Formosan species, appears to be of little importance.

The wood of *C. lanceolata* is readily separated microscopically from all other conifers except *Glyptostrobus*, *Thuja* species and *Thujopsis* by F 26 (typical taxodioid cross-field pitting), F 14 (abundant parenchyma with only inconspicuous thickenings on the cross-walls) and F 21 (well-marked indentures). It is distinguished from these woods macroscopically by its reddish-brown, fragrant heartwood and narrow but well-defined dense latewood, and microscopically, from *Thuja* by its parenchyma not being confined to the latewood, from *Glyptostrobus* by its rays having cross-field pits arranged in a single row, except in marginal cells, and from *Glyptostrobus* and *Thujopsis* by its rays having relatively thick end walls, approaching the horizontal walls in thickness.

References :—Fujioka (1913), Kanehira (1926), Peirce (1936), Tang (1933).

**GLYPTOSTROBUS.** The sole species of this genus, *G. pensilis*, is a small tree of South China of no economic importance ; it is now almost unknown in the wild state (Henry and McIntyre, 1926). The wood may be distinguished from most conifers by means of F 26 (taxodioid cross-field pits), F 14 and 15 (abundant parenchyma with slightly nodular cross-walls), and from the remainder by the frequent arrangement of the cross-field pits of the middle cells of the rays in more than one horizontal row per field.

*References* :—Kanehira (1926), Tang (1933).

**SCIADOPITYS.** The only species of this genus, *S. verticillata*, produces timber resembling slowly grown pine. It is of some commercial importance in central Japan.

The wood is distinct from most conifers in respect of F 23 (large cross-field pits), F 1 (well-defined growth rings), F 28 and F 13 (resin ducts and parenchyma absent). These features it shares only with *Phyllocladus* which, however, differs in frequently having pairs of cross-field pits per ray field instead of almost exclusively solitary pits as in *Sciadopitys*, and narrower rays. *Sciadopitys* possesses a peculiar spicy-resinous odour whereas *Phyllocladus* has practically none.

*References* :—Fujioka (1913), Kanehira (1926), Peirce (1935, 1936).

**SEQUOIA.** Of the two existing species of this genus, *Sequoia sempervirens* is an important timber tree of the coast regions of south-west Oregon and California, while *S. gigantea* is limited to some 26 scattered groves in California (Record, 1934) and its timber is too scarce for more than local use.

*Sequoia*, together with the related genera *Athrotaxis*, *Cunninghamia*, *Cryptomeria*, *Glyptostrobus*, and *Taxodium*, *Thuja*, and also *Thujopsis*, is distinguished by F 26 (taxodioid cross-field pits), F 14 and 15 (wood parenchyma abundant and with nodular cross-walls). *Sequoia* itself is then separated from these genera by its purplish-brown heartwood and also by its tall, large-celled \* and frequently biseriate rays. In addition, the relatively inconspicuous nodules on its parenchyma cross-walls distinguish *Sequoia* from *Cryptomeria*, *Taxodium* and *Thujopsis* ; the large size of its cross-field pits also distinguishes it from *Thujopsis* and their arrangement from *Glyptostrobus*.

*References* :—Bailey and Faull (1934), Gordon (1912), Mitchell (1936), Peirce (1936).

**TAIWANIA.** The sole species of this genus, *T. cryptomerioides*, is a tree attaining 200 ft. in height and 20 ft. in girth found in Formosa, parts of China and North Burma ; it is apparently of only local economic importance. The much discussed Chinese Coffin Tree is now believed to be this species (Kermode, 1939).

\* *S. sempervirens*, which appears to have the largest ray cells in the Coniferae (usually over 25 microns in width), has a polyploid number of chromosomes in its nuclei (Sax, 1933), a condition which is rare in this group and is commonly associated with the development of unusually large cells.

The wood is soft, light in weight, and has heartwood of a pale brown colour with dark purplish-brown streaks which readily distinguishes it from other softwoods. Microscopically it may be distinguished except from *Chamaecyparis Lawsoniana* and *Fokienia* by F 25 (cupressoid cross-field pits), F 18 and 19 (fairly thick, but unpitted horizontal walls of the ray cells and F 14 (presence of abundant parenchyma). The relatively large size of the cross-field pits distinguishes *Taiwania* from *Chamaecyparis*, and the colour of the heartwood and absence of both odour and taste distinguish it from both *Chamaecyparis* and *Fokienia*; these two genera also have nodular thickenings on the cross-walls of their parenchyma cells (F 15), a feature of extremely rare occurrence in *Taiwania*.

**TAXODIUM.** *Taxodium distichum*, the sole representative of this genus, is widely distributed on wet ground from Florida through the Gulf states to Mexico, where it is represented by the variety *mucronatum*.

This species is fairly readily separated from all other conifers except other members of the Taxodiaceae by F 26 and 25 (ray cross-field pitting) \*, F 14 and 15 (abundant parenchyma with nodular cross-walls, F 18 (presence of thick-walled ray cells) and F 9 (multiseriate tracheid pitting). Comparative macroscopic examination will generally serve to separate *Taxodium* from *Sequoia*, *Athrotaxis* and *Cunninghamia*, which have this combination of features. The heartwood of *Taxodium* is said to vary from light yellowish-brown (inland grown material) to red or even black (swamp grown material). All ten specimens examined were of a light brown colour, and quite distinct from heartwood of any other species. The thin bands of very dense latewood contrasting with the particularly large-lumened springwood tracheids are very characteristic of *Taxodium*, as is the slightly sour odour and rather greasy appearance commonly exhibited.

Microscopically, the consistent development of well-marked nodular thickenings on the cross-wall of the parenchyma cells contrasts with their sporadic or rudimentary development in the other taxodiad genera mentioned above. The frequent presence of 2-4 rows of tracheid pits, lack of indentures and the small apertures commonly shown by the cross-field pits, are additional features useful in separating *Taxodium*.

**References** :—Mattoon (1915), Peirce (1936).

**CUPRESSACEAE.** The fifteen genera of this family are mostly confined to the temperate regions of either the north or south hemisphere; *Libocedrus* alone occurs in both hemispheres and is one of the few genera with representatives in the tropics. With the exception of *Diselma*, *Actinostrobus* and *Microbiota* all the genera include species attaining tree size.

\* The individual pits are often of the cupressoid type, but commonly form a single horizontal row of 3-4 pits, an arrangement rarely found outside the Taxodiaceae.



The timber-producing members of the family have the following features in common : latewood never conspicuous (F 3), alternate pitting lacking (F 8), tracheids without spiral thickenings (F II) (but special thickenings in *Callitris* (F 12)), parenchyma present and frequently abundant (F 13, F 14), cupressoid cross-field pits (F 25) (except in *Thuja*) and no resin ducts.

Three subdivisions of the family are recognized, but these do not appear to coincide with any classification based on the anatomy of the wood. They are :

(I) *Thujoideae* :—*Actinostrobus*, *Callitris*, *Tetrclinis*, *Callitropsis*, *Widdringtonia*, *Fitzroya*, *Diselma*, *Thujopsis*, *Thuja*, *Libocedrus* and *Fokienia*.

(II) *Cupressoideae* :—*Cupressus* and *Chamaecyparis*.

(III) *Juniperoideae* :—*Arceuthos* and *Juniperus*.

**MICROBIOTA.**—A monotypic genus of uncertain position in the classification.

Although individual recognition of most of the timber-producing species of Cupressaceae is practicable from examination of their anatomy, the genera are too heterogeneous anatomically for separation genus by genus.

**ARCEUTHOS.** *A. drupacea* (Labill.) Ant. & Kosch., the sole representative of this genus, is commonly known as *Juniperus drupacea* Labill., and is a tree up to 60 feet high found in the mountains of Asia Minor, Syria and Greece. It forms pure woods and also grows mixed with other conifers and is probably used locally. The wood anatomy of this species has not been described; from examination of twig material it appears similar in microscopic features to the representatives of *Juniperus* examined and in particular to the American species *J. lucayana* and *J. virginiana* in having ray cells with fairly thick horizontal walls and nodular end walls.

**CALLITRIS.** The timbers of this Australasian genus are particularly dense and hard for softwoods. This feature, together with the frequently indefinite rings (F 1) and lack of distinctive colour is usually sufficient for the recognition of *Callitris* species.

The species of most importance in Australia is *Callitris glauca*. *C. Macleayana*, *C. calcarata*, *C. arenosa*, *C. intratropica* and *C. gracilis*, in order of probable importance, are others from which some timber is obtained. (C.S.I.R. 1938.) *Callitris glauca* has well-developed thickening bands (F 12) surrounding the bordered pits of the tracheids, a feature found solely in a few species of this genus. Of the other species mentioned *C. calcarata* and probably *C. gracilis* (judging from a photomicrograph in Baker & Smith, 1910) have similar thickenings : in *C. arenosa* and *C. intratropica* the thickenings are less frequent and less strongly developed and in *C. Macleayana* they are entirely lacking. The last species may be distinguished from most conifers by F 14 (abundant parenchyma), F 25, 18, and 19 (rays with cupressoid cross-fields and thin unpitted horizontal walls), and from the remainder (*Widdringtonia* spp., and white-wooded *Podocarpus* spp.) by the well-marked zonation of the parenchyma and also by macroscopic features.

**References** :—Budkevich (1936), Patton (1927), Peirce (1937).

**CALLITROPSIS.** This is a recently described genus, of which only a single species is known, *C. araucarioides* Compton, a tree 30–35 ft. high, found only in a single locality in New Caledonia.

The following data are based on the description and photomicrographs of Prince (1938) and on Peirce's (1937) description. Wood fragment, greyish-yellow in colour and of an oily appearance; growth rings often microscopically indistinct. Tracheids all rounded in cross-section; only occasional biseriate pitting in earlywood; special thickenings of any type apparently absent. Wood parenchyma fairly abundant and mostly scattered; transverse walls smooth. Ray tracheids said to be present, but apparently rare as in most other Cupressaceae. Rays are 1 to 24 cells high, partly biseriate; composed of broadly-elliptical or circular cells frequently having dark contents, particularly in heartwood; horizontal walls thin and only sparsely pitted; end walls smooth; indentures absent. Ray cross-field pits of the cupressoid type, 2 to 5 per field. Resin ducts lacking.

The above microscopic features isolate this wood except from *Cupressus lusitanica*, which differs in having a pale reddish-brown heartwood which has neither fragrance nor an oily appearance.

**CHAMAECYPARIS.** Of the six species of *Chamaecyparis*, four, viz. *C. Lawsoniana*, *C. nootkatensis* and *C. thyoides* (North America) and *C. obtusa* (Japan) yield commercial timbers, the first named furnishing regular supplies for export. These timbers are light in weight, slightly to extremely aromatic and very durable; the heartwood of the first two species is yellowish, and that of the latter two is of a pinkish colour.

*C. nootkatensis* is separated anatomically from all other conifers by F 16 (ray tracheids regularly present) F 28 (lack of resin ducts) and F 20 (horizontal walls of ray cells only moderately pitted). This wood is exceptional also in having an odour reminiscent of turnips or raw potatoes.

The other three commercial species of *Chamaecyparis* are separated from most conifers by F 1 (distinct growth rings), F 14 (abundant parenchyma), F 25 (cupressoid cross-field pits) and F 22 (end walls of ray cells smooth). *C. Lawsoniana* and *C. obtusa* differ from each other macroscopically, the former having a strongly scented yellowish heartwood and the latter a faintly scented pinkish heartwood. The above combination of microscopic features together with F 15 (parenchyma with nodular end walls) and F 19 (ray cells with pitted horizontal walls) is shared by these two species with *Cupressus* spp. which differ macroscopically (cream-coloured harder woods not sweetly scented), *Libocedrus tetragona* which differs in having ray cells with abundant dark contents and commonly with horizontal walls thickened at the point of insertion of the end wall, and *Taxodium*, which is distinct macroscopically, and usually also in having its cross-field pits in horizontal rows of more than two per field. *C. thyoides* differs from the two preceding species of *Chamaecyparis* in having very low rays (maximum height about 12 cells) with thin horizontal walls (F 18).

It shares this combination of features only with *Libocedrus Bidwillii*, which is separated by the presence of abundant dark cell contents in its rays.

*References* :—Fujioka (1913, 1933), Miyoshi (1934), Peirce (1937), Phillips (Nov. 1937).

**CUPRESSUS.** Of the dozen species of *Cupressus* (as distinct from *Chamaecyparis*) recognized, none produce timber of commercial importance in the world market, although that of *C. funebris* (China), *C. sempervirens* (S. Europe) and *C. torulosa* (India) are of some local importance. *Cupressus macrocarpa*, and to a less extent *C. lusitanica*, have been planted in many countries, and these timbers may be more commonly met with in the future.

*Cupressus* is distinguished microscopically from most other conifers by F 14 (abundant parenchyma), F 19 and 22 (ray cells with pitted horizontal walls and smooth vertical walls) and F 25 (cupressoid cross-field pits), and from the remainder by the somewhat circular shape of the tracheids as seen in transverse section (compression wood excluded) and by the frequently biseriate rays. *C. funebris* and *C. lusitanica* have rays with thin horizontal walls (F 18) and parenchyma with smooth cross walls (F 15); this separates them from all except *Podocarpus dactyloides*, which is distinct on account of its lack of dark cell contents in the rays.

Compared with *Chamaecyparis* (which is often regarded as a subgenus of *Cupressus*) the woods are rather harder and although frequently slightly aromatic, lack the sweet spicy odour of *Chamaecyparis*; the rays are typically higher, and their horizontal walls often more strongly pitted.

*References* :—Peirce (1937), Phillips (Nov. 1937), Tang (1933).

**FITZROYA.** *Fitzroya cupressoides* F. M. Johnston (more widely known as *F. patagonica* Hook. fl.), the sole representative of this genus, is of importance as a timber tree in Chile and northern Patagonia, and some attempt has been made recently to export the wood.

Microscopically *Fitzroya* is readily distinguished from all conifers except *Juniperus lucayana*, *J. virginiana* and *Libocedrus decurrens* by means of F 25 (cupressoid cross-field pits), F 14 and 15 (abundant parenchyma with nodular cross-walls), and F 22 (rays with nodular end walls). The arrangement of the cross-field pits of the middle cells of the ray and also the absence of intercellular spaces between the tracheids separates *Fitzroya* from *Juniperus*. Its deeply coloured, but unscented heartwood renders it distinct from all these species.

In colour *Fitzroya* closely resembles the orange-red heartwood of *Taxus*, but this bright colour tones down to a darker brown recalling that of *Thuja plicata* and *Libocedrus Bidwillii*. Microscopic examination readily separates both *Taxus* and *Thuja* from *Fitzroya*, and the brighter colour of freshly cut surfaces of the latter distinguishes it from *Libocedrus*.

*References* :—Bernath (1937), Bredemann (1938), Dallimore (1933), Peirce (1937).

**FOKIIENIA.** Three species endemic to China are known, viz. *F. Hodginsii*, *F. Maclurei* and *F. Kawaii*; these form small trees of no apparent importance as timber producers.

The wood of *F. Hodginsii* is distinguished, except from some material of *Chamaecyparis Lawsoniana*, by means of F 14 and 15 (abundant parenchyma with nodular cross-walls, the nodules being poorly developed compared with those in *Chamaecyparis Lawsoniana*) and F 25, 22, and 19 (rays with cupressoid cross-field pits, smooth end walls and unpitted horizontal walls). No material of the other species was available.

According to Tang (1933), *F. Maclurei* has dark brown heartwood with a yellowish tinge (this agrees with *F. Hodginsii*) distinctly demarcated from the narrow zone of light reddish-brown sapwood. This wood is said to be of very slow growth, and weighs 34 lb. per cu. ft. air-dry.

*References* :—Burdon (1911), Kanehira (1926), Metcalfe (1931), Peirce (1937), Tang (1933).

**JUNIPERUS.** The only species of *Juniperus* of present commercial importance are the American Pencil cedar *J. virginiana* (and *J. lucayana* Britt.\*) and the East African *J. procera*.

These woods are readily distinguished from all other conifers by the peculiar cedar-like odour which one normally associates with pencils.

Microscopically these species are separated from most other woods by F 14 and 15 (abundant parenchyma with nodular transverse walls) and F 25 (cupressoid cross-field pits).

*Juniperus procera* is then distinguished from the American junipers and all other woods by F 18 (rays with thin horizontal walls); alternatively *J. virginiana* and *J. lucayana* are similarly isolated by F 22 (nodular thickenings on the vertical end walls of the rays) from all other species except *Libocedrus decurrens* from which *J. virginiana* may be distinguished by the regular presence of well-marked intercellular spaces at the corners of the tracheids (transverse section) in normal wood. The cross-field pits, which occasionally tend to be of taxodioid type, are usually much larger and more regularly arranged in both these *Juniperus* species than in *Libocedrus*.

*References* :—Fujioka (1913), Rushton (1915), Tang (1933), Tubeuf (1916), Chalk et al. (1932).

**LIBOCEDRUS.** The most important species is the North American *L. decurrens*. The New Zealand *L. Bidwillii* with which is sometimes associated an almost negligible quantity of *L. Doniana* (Ward, 1926), is of limited commercial value. *L. tetragona* (= *L. uvifera*) and *L. chilensis* are described by Record and Mell (1924) as important timber trees of Chile, but there is no mention of their use outside that country; according to Bernath (1937) only the former species is exploited commercially.

\* This species has much more limited distribution in America than *J. virginiana*, being found in the extreme South-East; it is also found in the W. Indies.

The three species included in the key differ in several respects. *L. decurrens* is readily distinguished microscopically except from *Fitzroya cupressoides*, *Juniperus virginiana* and *J. lucayana* by F 14 (presence of abundant parenchyma) and F 22 (strongly pitted vertical end walls of the ray cells). Macroscopically these woods are quite distinct, *Juniperus* and *Fitzroya* being distinctly more reddish in general colour and particularly in the colour of the rays. (See also under *Fitzroya* and *Juniperus*.)

The more strongly developed pitting of the horizontal walls of the ray cells, the regularly aligned and relatively larger pits occupying a large portion of the earlywood cross-fields and the more rounded cross-sectional shape of the tracheids distinguish the *Juniperus* species.

*L. Bidwillii* may be distinguished from all woods except *Chamaecyparis thyoides*, by means of F 14 (abundant parenchyma), F 25 (cupressoid cross-field pits), F 18 and 19 (rays with thick, smooth horizontal walls), and F 15 (parenchyma with smooth cross walls), and differs from this species in having a dark brown heartwood (F 2).

*Libocedrus tetragona* has been separated by Florin (1930) as the type for a new genus under the name *Pilgerodendron uviferum* (Don) Florin. To judge from the limited information and material available the timber agrees with *L. decurrens* in general character, but differs microscopically in having very low rays (1-9, mostly 1-4 cells high), only inconspicuous nodular thickening on the horizontal walls of the parenchyma and in having practically smooth end walls to the ray cells. It may be separated together with the other species of *Libocedrus*, from most conifers by means of F 14, F 25, F 18 and F 19, and from the remainder by the smooth end walls of the ray cells (F 22), slightly nodular cross walls of the parenchyma (F 15) and very low rays.

*References* :—Bernath (1937), Metcalfe (1931), Mitchell (1918), Pierce (1937), Ward (1926).

**TETRACLINIS.** The sole representative of this genus, *T. articulata*, is native to Algeria, Morocco, Mogador, and Malta, and has been planted in French North Africa. The wood, which is used to a small extent for fancy cabinet work, is reputed to be the 'citrus wood' of the ancient Romans (Dallimore and Jackson, 1931). This species also furnishes the so-called 'Thuja burr' (Holland, 1935, Howard, 1934, Meyer, 1936, Provasoli, 1929).

*Tetraclinis articulata* may be distinguished microscopically from all other woods except *Callitris Mackayana* by F 1, F 8, and F 12 (lack of definite growth rings, alternate tracheid pitting and callitroid thickenings), F 25 (typical cupressoid cross-field pits) and F 19 (rays with unpitted horizontal walls); darker heartwood and sparse parenchyma distinguish it from *Callitris*. The dark brown colour of the heartwood of *Tetraclinis* is distinctive amongst timbers having poorly defined growth rings.

*References* :—Anon. (1937). Peirce (1937).

**THUJA.** Two species yield timber of commercial importance, viz. *T. occidentalis* of eastern North America and the better known *T. plicata* of western North America. Two eastern Asiatic species, *T. orientalis* (see below) and *T. Standishii* of Central Japan, yield a small amount of timber for local use.

*Thuja* is distinguished from most conifers by F 26 (taxodioid cross-field pits), F 18, 20 and 21 (rays with thick, but sparsely to only moderately pitted horizontal walls and clearly marked indentures) and F 1 (clearly defined growth rings). *T. plicata* and *T. Standishii* (= *T. japonica*), which appear indistinguishable, are then separated from the remaining conifers (*Dacrydium intermedium*, certain Taxodiaceae and *Thujopsis*) by their dark and characteristically scented heartwood, and also by the narrow but thick-walled latewood zones, the abundant dark contents and narrow width of their ray cells, and from the Taxodiaceae by the occasional presence of ray tracheids. *T. occidentalis* differs from these two species in having no dark heartwood; it agrees in most microscopic features but points of difference are: parenchyma sparse (in the other species it is abundant where present) and the occasional presence of nodular thickenings on the end walls of the ray cells, especially near the ring boundaries.

*T. plicata* and *T. Standishii* bear a superficial resemblance to *Cryptomeria japonica*, *Cunninghamia lanceolata*, *Libocedrus Bidwillii*, and *Sequoia sempervirens*, all of which are soft lustrous woods of low density typically having dark brown or reddish-brown heartwood. The following combination of features shown by *Thuja* serve to distinguish them from these woods; thick-walled latewood, parenchyma (if present) practically confined to latewood, rays narrow and with clearly marked indentures and abundant dark contents. The presence of abundant zonate parenchyma with nodular thickening distinguishes the wood from *Thuja*.

*Thuja orientalis* Linn., a bush or small tree up to 40 feet high, grown in various parts of Asia, constitutes the subgenus *Biota* in Pilger's classification, but by some is accorded full generic rank as *Biota orientalis* Endl. The wood, which may be used to a limited extent locally, is scented, has a relatively high average density, about 33 lb. per cubic foot air dry (compare 21 lb. for *T. occidentalis* and 24 lb. for *T. plicata*), and has an orange-brown to dark brown heartwood. Anatomically the wood is distinguished from other *Thuja* species by its cupressoid cross-field pits.

**References:**—Eades and Alexander (1934), Fujioka (1913), Kanehira (1926), Metcalfe (1931), Peirce (1937).

**THUJOPSIS.** *Thujopsis dolabrata* Sieb. & Zucc. is sometimes included in the genus *Thuja* as *T. dolabrata* Linn. fil. Its timber is of some importance in Japan.

The presence of abundant parenchyma, not confined to the latewood, with nodular cross-walls (F 14 and 15) and taxodioid cross-field pits (F 26) distinguishes the wood from all conifers except certain Taxodiaceae; from these it is separated by the small size of its cross-field pits.

**References:**—Fujioka (1913), Kanehira (1926), Peirce (1937), Prince (1938).

**WIDDRINGTONIA.** Two species of *Widdringtonia* yield timber which may prove of some importance in the South African market, viz., *W. juniperoides* (Clanwilliam cedar, Cape Province), and *W. Whytei* (Milanji cedar, Nyasaland).

These woods may be readily distinguished microscopically by means of F 25 (cupressoid cross-field pits), F 14 (abundant parenchyma), F 18 and 19 (rays with thin, unpitted horizontal walls) and F 12 (no callitroid thickenings) from all conifers except *Callitris Macleayana* and *Podocarpus* spp. From these *Widdringtonia* spp. may be distinguished by their strong cedar-like odour and pronounced taste, and also from *Podocarpus* spp. by the dark contents of the ray cells; these render the rays visible to the naked eye and impart colour to the wood.

The two species of *Widdringtonia* considered are rather difficult to separate with certainty. Growth rings are rather more distinct in *W. juniperoides* and there is less tendency to biseriate tracheid pitting in this species.

*Reference* :—Chalk, Burt-Davy et al. (1932).

The following notes deal with those genera of Cupressaceae which contain only shrubby species.

**ACTINOSTROBUS.** The two species of this genus, which is allied to *Callitris*, are shrubs of limited distribution in Western Australia. *A. pyramidalis* is a bush up to 8 feet high; *A. acuminatus* is a still smaller shrub. The following notes, compiled from the literature, refer to *A. pyramidalis*.

Heartwood, darker in colour than the pale sapwood, is said to be produced. Odour is lacking. Growth rings often indistinct microscopically, tracheids squarish in cross-section in earlywood, sometimes rounded in latewood, with uniseriate pitting and no special thickenings; latewood tracheids not strongly thickened. Parenchyma abundant, of variable distribution, but commonly confined to the latewood and zonate; horizontal walls smooth. Rays up to 24 cells high, but commonly low, uniseriate, or occasionally partly biseriate; horizontal walls with occasional pits, end walls unpitted; indentures absent; cross-field pits apparently of the cupressoid type, 2 to 4 per field.

Twig material of *A. acuminatus* only was available to the present writer. This showed the following features additional to the preceding description :—(1) horizontal walls of rays thin but with occasional small pits; (2) pairs of thickening bands associated with the apertures of the bordered pits (cf. *Callitris*) present in occasional tracheids.

*References* :—Baker and Smith (1910), Patton (1927), Peirce (1937), Prince (1938).

**DISELMA.** *D. Archeri*, the sole representative of the genus, is an erect bush or small tree up to 20 feet high, its habit varying considerably according to growth conditions; it is confined to the highlands of western Tasmania.

The wood is fairly hard and has a plum-coloured heartwood. Growth rings

are typically very narrow and microscopically distinct. Tracheids all rectangular in cross-section, thick walled, those of the latewood with lumina practically obliterated; pitting uniseriate. Parenchyma abundant, distribution variable; horizontal walls with nodular thickenings. Rays up to 12 cells high, commonly biseriate, cells circular in tangential section; horizontal walls with frequent pits; end walls nodular; indentures absent; cross fields with two to four small pits of the cupressoid type.

(NOTE.—As pointed out by Patton (1927) Kanehira's (1926) fig. 47, labelled *Pherosphaera Hookeriana*, probably refers to *Fitzroya (Diselma) Archeri*, and appears to have been interchanged with fig. 77.)

References :—Kanehira (1926), Patton (1927), Peirce (1937), Prince (1938).

MICROBIOTA \*. *Microbiota decussata*, established by Komarov in 1923 as the type of a new genus, is a small, densely branched shrub found in alpine localities of eastern Siberia. Its systematic position within the Cupressaceae is uncertain. No description of the wood is available.

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The investigation was based on the Laboratory's collection of Coniferae comprising about 1400 wood specimens of some 300 species. This has been built up during the past fifteen years from a wide variety of sources, and thanks are due to the staffs of the research institutes and forest services throughout the world and to the commercial firms and private donors, too numerous to mention individually, who have contributed to this collection.

#### SUMMARY.

The first part of the paper describes a multiple-entry card key to coniferous woods. The features employed, which were only selected after extensive investigation, are illustrated and described. Data on over one hundred of the more important tree species of forty genera are given in tabulated form suitable for ready reference and for transference to key cards.

In the second part of the paper, the composition, distribution, and wood anatomy of the seven families of Coniferae are briefly dealt with, and under each genus the diagnostic features and methods of identifying the individual species are indicated with particular reference to timber-producing species.

\* This is the spelling as given in 'Index Kewensis' and English publications; Pilger (1926), however, consistently uses the spelling *Macrobiota*.



Some discrepancies in the existing botanical classification are apparent from this anatomical study.

A select bibliography on coniferous wood anatomy is appended, and also a combined index and check-list.

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The references noted are a selection of the more important papers, and do not purport to constitute a comprehensive bibliography of the subject. The references marked '†' however, include extensive bibliographies which it is unnecessary to reproduce here. Those marked with an asterisk contain information on the majority of the genera.

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## DESCRIPTION OF PLATES 13 TO 15.

(T.S.=Transverse section; T.L.S.=Tangential longitudinal section;  
R.L.S.=Radial longitudinal section.)

All sections are of adult stem wood.

## PLATE 13.

- Fig. 1. *Callitris glauca*. T.S.  $\times 50$ , showing indistinct growth rings. Note also the rounded tracheid lumina (contrast the angular lumina in fig. 2). (Feature No. 1.)
- Fig. 2. *Larix decidua*. T.S.  $\times 20$ , showing conspicuous latewood. (Feature No. 3.)
- Fig. 3. *Pinus contorta* var. *latifolia*. Tangential surface,  $\times \frac{1}{2}$ , showing dimpled grain. (Feature No. 7.)
- Fig. 4. *Agathis vitiensis*. R.L.S.  $\times 175$ , showing tracheids with alternate arrangement of the bordered pits. (Feature No. 8.)
- Fig. 5. *Taxodium distichum*. R.L.S.  $\times 175$  showing tracheids with opposite arrangement of the bordered pits. (Feature No. 9.)
- Fig. 6 A. *Cedrus brevifolia*. R.L.S.  $\times 1000$ , showing tracheid pits with scalloped torus margins. (Feature No. 10.)
- Fig. 6 B. *Dacrydium Franklinii*. R.L.S.  $\times 1000$ , showing characteristic torus extensions.
- Fig. 7 A. *Taxus baccata*. T.L.S.  $\times 120$ , showing tracheids with spiral thickenings. (Feature No. 11.)
- Fig. 7 B. *Pseudotsuga taxifolia*. T.L.S.  $\times 120$ , showing same as 7 A.
- Fig. 8. *Callitris glauca*. R.L.S.  $\times 175$ , showing tracheids with thickenings across the pit borders. (Feature No. 12.)
- Fig. 9. *Callitris glauca*. T.L.S.  $\times 175$ , as fig. 8, but with thickenings in sectional view.
- Fig. 10. *Juniperus virginiana*. T.S.  $\times 175$ , showing intercellular spaces between normal tracheids.
- Fig. 11. *Picea abies*. T.S.  $\times 175$ , showing rounded outlines of compression wood tracheids and associated intercellular spaces.
- Fig. 12. *Picea abies*. R.L.S.  $\times 175$ , showing spiral checking in walls of compression wood tracheids.

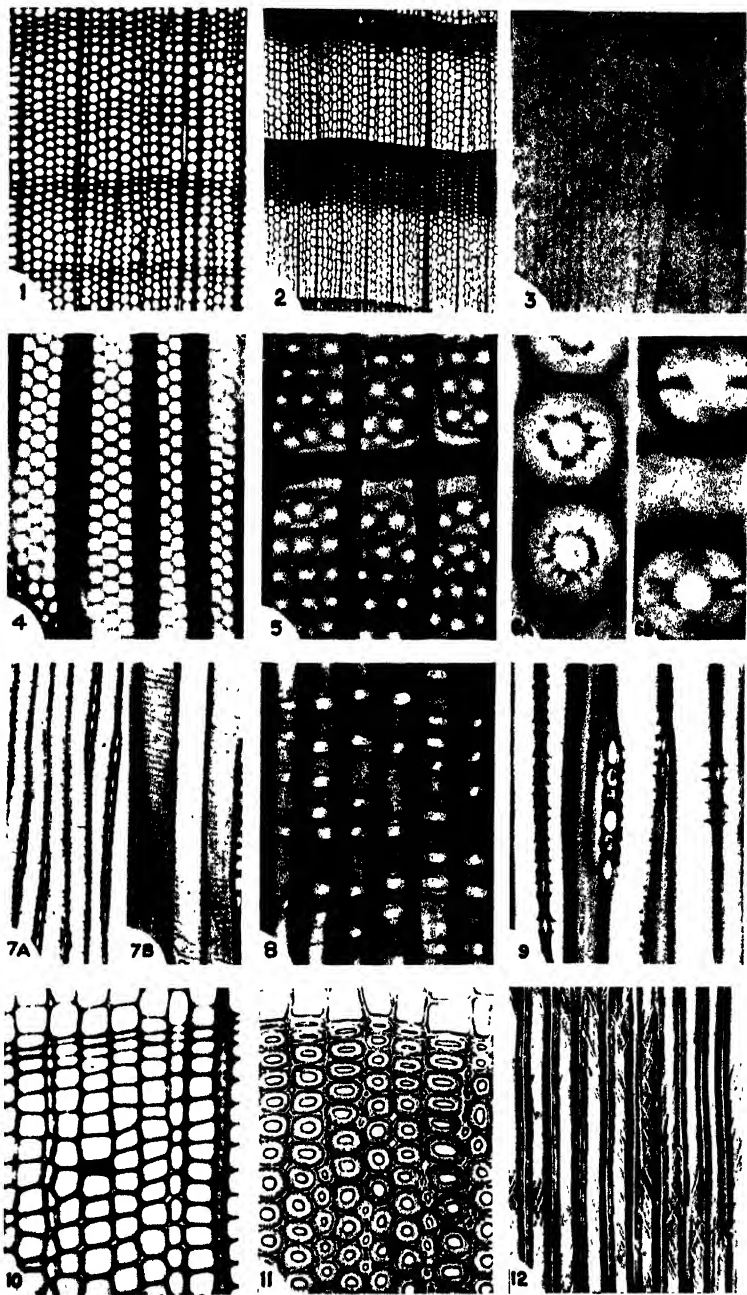
## PLATE 14.

- Fig. 13. *Pinus monticola*. R.L.S.  $\times 175$ , showing ray tracheids. (Feature No. 16.) In this instance the ray tracheids are marginal and have thin smooth walls. Cf. figs. 25, 26, 29 and 30.

- Fig. 14. *Sciadopitys verticillata*. R.L.S.  $\times 175$ , showing ray with thin unpitted horizontal (and vertical) walls. (Features Nos. 18 and 19.)
- Fig. 15. *Abies alba*. R.L.S.  $\times 175$ , showing ray with well-pitted horizontal (and vertical) walls. (Feature No. 20.) Cf. figs. 18 and 30.
- Fig. 16. *Thuja occidentalis*. R.L.S.  $\times 600$ , showing indentures at angles of ray cells. (Feature No. 21.)
- Fig. 17. *Juniperus virginiana*. R.L.S.  $\times 175$ , showing ray cells with nodular end walls. (Feature No. 22.) Cf. figs. 15 & 25.
- Fig. 18. *Abies grandis*. R.L.S.  $\times 260$ , showing crystalliferous ray cells.
- Fig. 19 A. *Picea abies*. T.L.S.  $\times 175$ , showing ray having body cells elongated in sectional view.
- Fig. 19 B. *Picea sitchensis*. T.L.S.  $\times 175$ , showing ray having body cells approximately iso-diametric in sectional view. Cf. figs. 20 a & b.
- Fig. 20 A. *Taxodium distichum*. T.L.S.  $\times 175$ , showing approximately iso-diametric ray cells and also abundant pits on tangential wall of a latewood tracheid.
- Fig. 20 B. *Sequoia sempervirens*. T.L.S.  $\times 175$ , showing approximately iso-diametric ray cells with thickened corners.
- Fig. 21. *Cupressus macrocarpa*. T.L.S.  $\times 60$ , showing biseriate rays.
- Fig. 22. *Libocedrus decurrens*. T.L.S. (heartwood)  $\times 100$ , showing ray cells with dark contents.
- Fig. 23. *Taxodium distichum*. T.L.S.  $\times 175$ , showing parenchyma cells with nodular end walls.
- Fig. 24. *Chamaecyparis pisifera*. T.S.  $\times 25$ , showing parenchyma cells in zonate arrangement.

## PLATE 15.

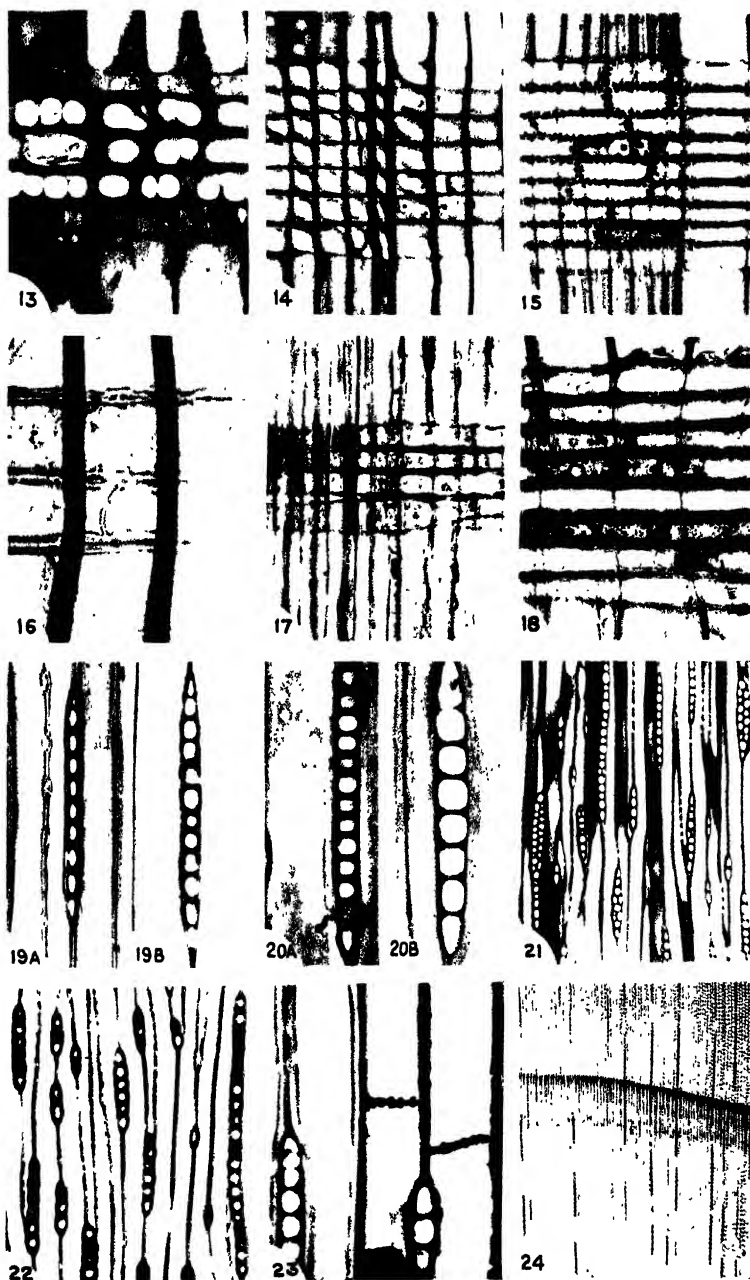
- Fig. 25. *Pinus sylvestris*. R.L.S.  $\times 260$ , showing large cross-field pits. (Feature No. 23.) Cf. figs. 13 and 14. Note also dentate ray tracheids. (Feature No. 17.) Cf. figs. 29 & 30.
- Fig. 26. *Cedrus brevifolia*. R.L.S.  $\times 260$ , showing piceoid cross-field pits. (Feature No. 24.)
- Fig. 27. *Chamaecyparis thyoides*. R.L.S.  $\times 260$ , showing cupressoid cross-field pits. (Feature No. 25.)
- Fig. 28. *Thuja occidentalis*. R.L.S.  $\times 260$ , showing taxodioid cross-field pits. (Feature No. 26.)
- Fig. 29. *Pinus palustris*. R.L.S.  $\times 260$ , showing several pinoid pits per cross-field. (Feature No. 27.) Note also reticulate thickenings of ray tracheids. Cf. figs. 25 and 30.
- Fig. 30. *Pinus halepensis*. R.L.S.  $\times 260$ , showing pinoid cross-field pits. (Feature No. 27.) Note also inconspicuously dentate ray tracheids. (Feature No. 17.) Cf. figs. 25 & 29.
- Fig. 31. *Pinus sylvestris*. T.S.  $\times 175$ , showing vertical resin duct. (Feature No. 28.) Cf. fig. 32. Note also thin-walled epithelial cells.
- Fig. 32. *Larix occidentalis*. T.S.  $\times 175$ , showing vertical resin ducts. (Feature No. 28.) Note also thick-walled epithelial cells. (Feature No. 31.)
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- Fig. 35. *Pseudotsuga taxifolia*. T.L.S.  $\times 150$ , showing horizontal resin duct with six thick-walled epithelial cells. (Features 30, 31 & 32.)
- Fig. 36 A. *Picea sitchensis*. T.L.S.  $\times 150$ , showing horizontal resin duct with eight thick-walled epithelial cells. (Features 30, 31 & 33.)
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[Anatomical Features of  
CONIFEROUS WOODS

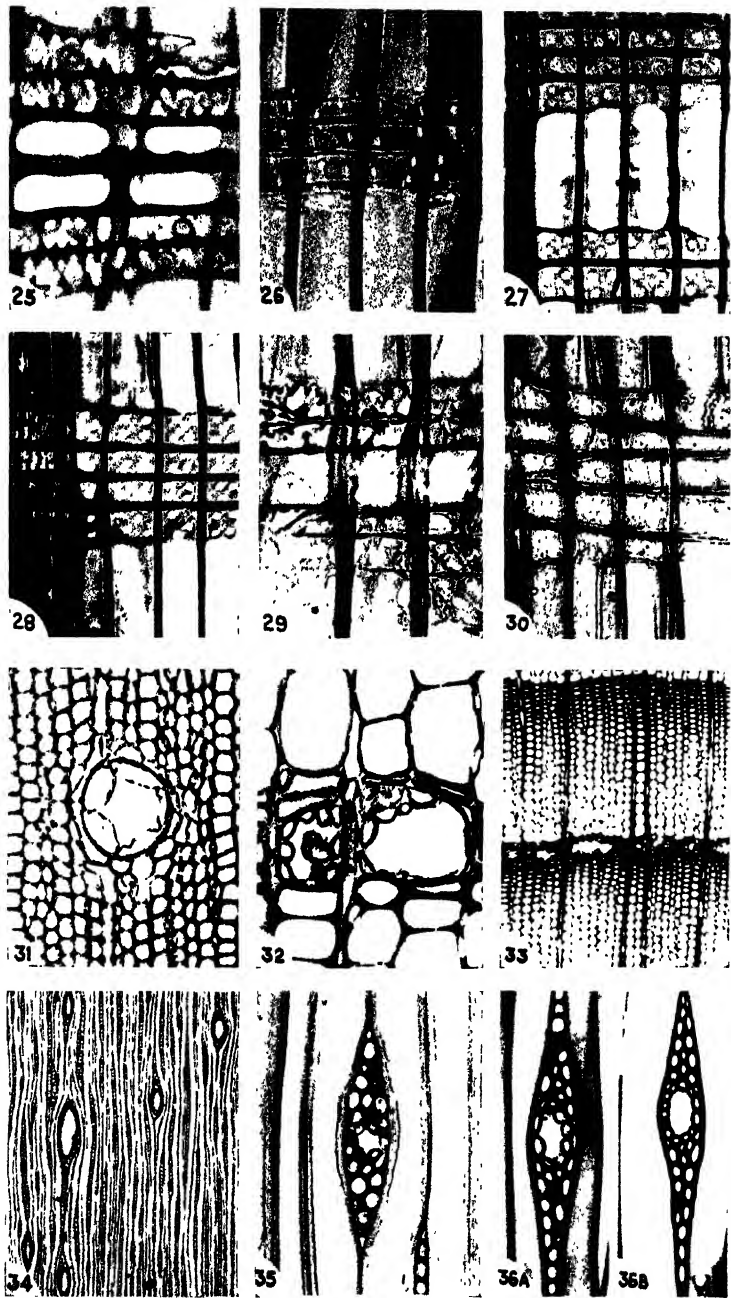






Anatomical Features of  
CONIFEROUS WOODS





Anatomical Features of  
CONIFEROUS WOODS



## INDEX AND CHECK-LIST

Where more than one page reference is given, that in heavy type indicates the main reference to the genus, species or feature concerned.

In most cases one common name only is listed for each of the species mentioned in the text. This is the standard name where such exists or otherwise that most generally used; for alternative common names see British Standards Institution, Publication 589 (1935), Dallimore and Jackson (1931), and Sudworth (1927). The botanical names used are in accordance with nomenclatural revisions made in recent years (see Dallimore, 1932 and 1933).

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The section Soldanelloideae of the genus *Primula*. By SIR WILLIAM WRIGHT SMITH, F.L.S. and HAROLD ROY FLETCHER, PH.D., D.Sc.

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THE section Soldanelloideae was instituted by Pax (in Engler's Bot. Jahrb. x, p. 186; 1889). He included eight species, as follows: *P. pinnatifida* Franch., *P. pusilla* Wall., *P. Reidii* Duthie, *P. sapphirina* Hook. f., *P. soldanelloides* Watt, *P. spicata* Franch., *P. uniflora* Klatt and *P. Wattii* King. If the first two are omitted, the remaining six form an adequate nucleus. But in 1905 in his Monograph of the Primulaceae in Engler's Pflanzenreich (iv-237, p. 65) Pax added: *P. cernua* Franch., *P. dryadifolia* Franch., *P. Fargesii* Franch., *P. incisa* Franch., *P. nutantiflora* Hemsl., *P. sinuata* Franch. and *P. tongolensis* Franch. Of these seven not one is now regarded as a legitimate member of the section. At the Primula Conference of 1913, in his admittedly tentative treatment of the Chinese species, Balfour restricted the content of the section as quoted by Pax to *P. spicata*, *P. incisa* and to five Himalayan species, excluding *P. pusilla*. (Journ. Roy. Hort. Soc. Lond. xxxix, p. 153; 1913). As new entrants he recorded *P. argutidens* Franch. and *P. Faberi* Oliver, now regarded as alien to the section, *P. nutans* Franch. and *P. penduliflora* Petitm. which is but a form of the previous species.

The report of the Primula Conference of 1928 (Notes Roy. Bot. Gard. Edinb. xvi, p. 1; 1928; Journ. Roy. Hort. Soc. Lond. lrv, p. 4; 1929) contains an analysis of the sections of the genus by Smith and Forrest, but without an evaluation of the individual species. In their statement the content of the section is given as eighteen species. These appear to be placed justifiably in Soldanelloideae with the exception of the peculiar *P. Fargesii* Franch., the position of which is doubtful, but it is not a Soldanelloid. *P. metria* Balf. f. & Cooper must also be deducted, as it is synonymous with *P. umbratilis* Balf. f. & Cooper. Consequently the number of species in the 1928 list retained in the section is sixteen to which are appended in the present paper six others described since that date: *P. flabelifera* W. W. Sm., *P. Jigmediana* W. W. Sm., *P. Ludlowii* W. W. Sm., *P. Sandemaniana* W. W. Sm., *P. Sherriffae* W. W. Sm. and *P. Wigramiana* W. W. Sm. Of these *P. Jigmediana* is somewhat aberrant and its proper allocation still a problem.

In the original diagnosis of the section by Pax (loc. cit.) the following data are still pertinent: the more or less pubescent leaves, never farinose; flowers solitary, capitate or spicate, sessile, reflexed or nodding; capsule rounded, not exserted. But other major criteria to be noted are: the usually bell-shaped corolla with the lobes more or less in line with the tube and not sharply bent back at right angles as in most Primulas; the almost invariable lack of an annulus; the occurrence in the majority of multicellular hairs on the leaves as in the *Muscarioides*. The species now referred to the section are in general conformity with the above definition. The only marked exception is *P. Jigmediana* which has pedicelled flowers and a flat annulate corolla. *P. Sherriffae* and *P. Ludlowii* have a very elongate corolla-tube and somewhat patent lobes, but their place in the section can hardly be challenged. The Soldanelloideae find their nearest allies in the *Muscarioides* and resemble them in habit and in the consistency and appearance of the leaves. The distinction lies almost entirely in the flower-structure. In the Soldanelloideae the cylindrical base of the corolla is as a rule short, gradually expanding into a much more prominent campanulate or infundibular limb. In the *Muscarioides* the corolla-tube is evenly elongate and predominates over the small patent limb. But the relationship is close and is confirmed by the cytology which has been investigated by Bruun (Cytological Studies in Primula, in Symb. Bot. Upsal. i, p. 81; 1932). In both cases the basic number

of chromosomes is ten and the nuclei of the two sections are so alike that they cannot be separated by cytological characters. The only other sections inviting comparison are *Capitatae* and *Denticulata*, which are without doubt more remote.

The centre of distribution of the section is in the Himalaya, as Pax indicated (loc. cit. p. 187). In his time only two of the now accepted species were known from outside that

### KEY TO THE SPECIES

(They are described in the following pages in alphabetical order)

Corolla 4-10 mm. long. not white. Leaves  $\pm$  1 cm. long:

Flowers sessile, exannulate:

Leaves not fan-shaped:

Leaves subglabrous; corolla 4-5 mm. long

Leaves with articulated hairs; corolla 1 cm. long

Leaves fan-shaped

Flowers stalked, annulate

Corolla 1.5-5 cm. long:

Corolla white:

Leaves 2-15 cm., hairy or pubescent. Scape many-flowered, bracteate:

Scape with long articulated hairs:

Calyx and corolla densely hairy

Calyx and corolla glabrous

Scape glabrous:

Leaves with long articulated hairs:

Corolla exannulate; lobes subpatent

Corolla annulate; lobes connivent

Leaves minutely pubescent

Leaves less than 1 cm., glabrous. Scape 1-flowered, ebracteate

Corolla purple, blue, violet or lilac:

Cylindrical base of corolla-tube very elongate, twice rest of corolla:

Scape 2-7-flowered

Scape 0; flower solitary

Cylindrical base of corolla-tube  $\pm$  equalling rest of corolla:

Flowers in spikes, occasionally in capitula (W. China and Siam):

Inflorescences compact, usually many-flowered

Inflorescences interrupted, usually few-flowered:

Leaves deeply crenate-dentate; corolla-lobes emarginate

Leaves slightly crenate; corolla-lobes subentire

Flowers in capitula (Himalaya and Tibet):

Corolla-lobes narrowly oblong:

Leaves finely pubescent; corolla 2.2-3 cm. long, lobes 6-15 mm.

Leaves with articulated hairs; corolla 1.7 cm. long, lobes 3 mm.

Corolla-lobes round, ovate or obovate:

Scape with long articulated hairs:

Calyx and corolla densely hairy

Calyx and corolla glabrous

Scape glabrous, farinose or finely pubescent:

Flowers generally solitary, larger than the leaves

Flowers rarely solitary, much smaller than the leaves:

Corolla campanulate; lobes entire

Corolla infundibular; lobes emarginate or erose:

Scape and calyx farinose

Scape and calyx efarinose:

Leaves finely pubescent; corolla-lobes emarginate

Leaves with long articulated hairs; corolla-lobes erose

*sapphirina*  
*fea*  
*strobilifera*  
*Jigmediana*

*Buryana*  
*umbratilis* var. *alba*

*Wigramiana*  
*Reidii*  
*eburnea*  
*soldanelloides*

*Sherriffae*  
*Ludlowii*

*nutans*

*spicata*  
*siamensis*

*Caudoriana*  
*siphonantha*

*Buryana* var. *purpurea*  
*umbratilis*

*uniflora*

*Wollastonii*

*Sandemaniana*

*chasmophila*  
*Wattii*

area—*P. nutans* and *P. spicata* from SW. China. The extensive exploration of the western provinces of China during the last forty years has not added to the number of Chinese species. *P. siamensis* is a third outlier. As the adjoining parts of Tibet may well be reckoned along with the Himalaya, the whole section with the above three exceptions is found in that range. Nearly all the species are high alpine with a four to six months'

covering of snow. *P. Sherriffae* and *P. Ludlowii* come from lower altitudes but experience a dry period from October to March.

The great majority of the twenty-two species are plants of very great beauty and explorers in the field have spent much time and trouble in securing seed. Only three, *P. fea*, *P. siphonantha* and *P. soldanelloides*, have not been flowered in cultivation. All the species are difficult under garden conditions, rarely producing ripe capsules, and their tenure in most cases is only too brief. *P. nutans* and *P. Sherriffae* are fairly well established and *P. Cawdoriana* promises to be so. As evidence of their desirability it may be pointed out that twelve have been figured in the 'Botanical Magazine', namely *P. Reidii* (t. 6961), *P. sapphirina* (t. 6961), *P. Wattii* (t. 8456), *P. nutans* (t. 8735), *P. chasmophila* (t. 8791), *P. spicata* (t. 8821), *P. eburnea* (t. 8901), *P. siamensis* (t. 9100), *P. Cawdoriana* (t. 9196), *P. Wollastonii* (t. 9401), *P. Wigramiana* (t. 9451) and *P. Sherriffae* (t. 9494).

The section at first sight seems to be easily separable into two subsections. One would contain dwarf delicate plants with small leaves as well as small flowers; the other robust plants with well-developed leaves and conspicuous flowers. A more careful examination shows that such an arrangement would sever species obviously related and could have no support on phyletic grounds. Consequently, in the above key an attempt has been made to give a more or less natural grouping.

*P. BURYANA* Balf. f. in Kew Bull. 1922, p. 151: W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929): W. W. Sm. in Notes Roy. Bot. Gard. Edinb. xvi, p. 227 (1931): *ibid.* xviii, p. 65 (1933): W. W. Sm. in Bot. Mag. t. 9401 (1935) sub *P. Wollastonii* Balf. f.

This species was collected by Dr A. F. R. Wollaston during the Mount Everest Expedition of 1921, at Lapche Kang, west of Mount Everest, at an altitude of 5000 m. It has since been found at stations in Eastern Nepal by Major Lal Dhwoj and by Professor K. N. Sharma. The type specimen, *Wollaston* 180, is in the Kew Herbarium. In the section the plant is at once distinguished by the long white articulated hairs on the leaves, scape, bracts and calyx. It came into cultivation from Nepal seeds, flowering in 1931, and still persists but is rare.

*Leaves* 3-5 cm. long, ovate or oblong-ovate, rounded at the apex, tapering into the winged petiole subequal to the blade, irregularly and deeply crenate-dentate, with numerous articulate hairs on both sides. *Scape* 8-18 cm. tall, shaggy throughout, bearing a head of 4-7 semi-pendent flowers; bracts lanceolate, densely hairy, often purplish. *Calyx* cup-shaped, 6 mm. long, hairy, efarinose, divided to the middle into subequal ovate lobes, obtuse or acute. *Corolla* funnel-shaped, 1.2-1.8 cm. long, white, rarely purple; tube 6-7 mm. long, pubescent, gradually widening into the limb; lobes 6-8 mm. long, 5-7 mm. broad, somewhat patent, obovate, deeply emarginate. *Long-styled flowers*: stamens inserted below the middle of the corolla-tube; style equalling the tube.

E. NEPAL. Old Duab Kund, *Lal Dhwoj* 233: Muklirath, *Sharma* 26: Pojosarg, *Sharma* 392: Panchpokree, *Sharma* 453.

A purple variety is here described: var. *purpurea* Fletcher var. nov.; a planta typica floribus purpureis nec albis differt.

E. NEPAL. Michet, *Sharma* 345A—type: *F. M. Bailey*.

*P. CAWDORIANA* Ward in Notes Roy. Bot. Gard. Edinb. xv, pp. 87, 96 (1926): W. W. Sm. & Forrest, *ibid.* xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, pp. 36, 37, fig. 40 (1929): McLaren, *ibid.* LIV, p. 67 (1929): Gould, *ibid.* LIV, p. 75 (1929): Stapf & Ballard in Bot. Mag. t. 9196 (1929): Ludlow in The Himalayan Journal, x, fig. facing p. 1 (1938).



This species is known only from SE. Tibet, where it was discovered by Ward in 1924 growing on steep rocky slopes at an altitude of 4000–4700 m. The type specimen is in the Kew Herbarium. The peculiar shape of its corolla distinguishes the plant from all the members of the genus except the allied *P. siphonantha*. In both the corolla has the form of a very elongate bell with narrow incised lobes. In habit and in foliage its affinity is clearly with the *Soldanelloideae*. Seeds secured by Ward produced flowering plants in 1926 which received an Award of Merit from the Royal Horticultural Society when shown by Mr A. K. Bulley of Neston. Further collections of seed have kept this striking species in cultivation, but it is rare.

*Leaves* forming a flat rosette, obovate, oblanceolate or spatulate, 2–4 cm. long, 1–1.5 cm. broad, obtuse or rounded at the apex, tapering into the broad petiole 5–10 mm. long, coarsely and irregularly dentate, finely scabrid above and below with whitish glandular hairs. *Scape* 6–15 cm. tall, slightly farinose towards the apex, bearing a head of 3–6 pendent flowers; bracts 5–7 mm. long, ovate-lanceolate or subrotund, forming a conspicuous purple crown. *Calyx* 6–8 mm. long, cup-shaped, green or purple-tinged, farinose within, cut to one-third into unequal oblong or broadly lanceolate obtuse lobes, entire or toothed. *Corolla* narrow-elongate, up to 3 cm. long, greenish-white below, violet-mauve above, minutely farinose towards the base; tube cylindrical for 5–8 mm., then passing gradually into the limb, 2–3 cm. across, with a large white eye; lobes narrow-oblong, 5–15 mm. long, not reflexed, cleft into 2–3 linear-triangular lobules. *Short-styled flowers*: stamens inserted at the apex of cylindrical part of tube; style 1.5–2 mm. long.

SE. TIBET. Temo La, Ward 5741—*co-type*. Chickchar, Tsari, Ward 11910; Po La, near Kyim Dzong, Ludlow & Sherriff 1928; Takar La, W. Tsari, Ludlow & Sherriff 2072; Bimbi La, Ludlow & Sherriff 2113; Chickchar, Ludlow & Sherriff 2154; Drichung La, near Charme, Ludlow & Sherriff 2305.

*P. CHASMOPHILA* Balf. f. ex Hutchinson in Bot. Mag. t. 8791 (1919) W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929).

This plant was first collected by Cooper in Bhutan in 1915, growing in peaty rock-crevices at an elevation of 5300 m. His specimens in advanced fruit were too imperfect for identification, but showed affinity with *P. umbratilis* Balf. f. & Cooper. Plants raised from Cooper's seed flowered at Edinburgh in 1917, but too feebly for an adequate description. But in 1918 a better plant, grown at Glasnevin from the same seed, was sent to Kew, was figured in the 'Botanical Magazine' and is preserved in the Kew Herbarium as the type. Good flowering material was secured by Ludlow and Sherriff in Central Bhutan in 1937. The species nearest akin is *P. Sandemaniana* W. W. Sm. which differs in its farinose scape, calyx and corolla. It was again introduced from seeds collected by Ludlow and Sherriff and flowered at Edinburgh in 1939, but is almost certainly no longer in cultivation.

*Leaves* slightly bullate, oblong-lanceolate to oblong-ovate, 3–8 cm. long, 1–2 cm. broad, rounded or obtuse at the apex, abruptly narrowed into the winged petiole as long as or longer than the blade, pinnately lobulate at the margin, efarinose, everywhere more or less puberulous. *Scape* 6–9 cm. high, minutely puberulous, bearing 1–5 subpendent flowers; bracts ovate, 3–4 mm. long, unequal. *Calyx* campanulate, 5–6 mm. long, finely puberulous without, divided to the middle into unequal lobes, entire or 2–4-toothed at the apex. *Corolla* funnel-shaped, about 2 cm. long and broad, deep violet; subcylindrical part of tube about 1 cm. long, puberulous without; lobes obovate to suborbicular, somewhat widely emarginate. *Long-styled flowers*: stamens inserted a little below the middle of the cylinder, style reaching its mouth.

BHUTAN. Joedawnchi, Cooper 4822: Dunshinggang, Ludlow & Sherriff 3301.

*P. Eburnea* Balf. f. & Cooper in Notes Roy. Bot. Gard. Edinb. ix, p. 166 (1916): W. W. Sm. & Forrest, *ibid.* xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929): Cooper in Notes Roy. Bot. Gard. Edinb. xviii, pp. 98, 109 (1933): Cowan in Bot. Mag. t. 8901 (1938). *P. Harroviana* Balf. f. & Cooper in Trans. Bot. Soc. Edinb. xxvii, p. 233 (1918): Ingwersen in Gard. Chron. ser. 3, LXV, p. 316, fig. 156 (1919).

First collected by Cooper in Bhutan in 1915 and later by Ludlow and Sherriff in SE. Tibet, this species grows on peaty turf, on glacial debris or under overhanging cliffs at an altitude of 4300–4800 m. The nearest allies are *P. Reidii* Duthie and *P. Wigramiana* W. W. Sm. from which it differs in the lack of multicellular hairs and in the shape of the corolla. Plants raised from Cooper's seed flowered in 1918–19 in various gardens. When exhibited in 1919 by Mr A. K. Bulley it obtained an Award of Merit from the Royal Horticultural Society. The plants of the original introduction died out and those resulting from seed collected by Ludlow and Sherriff in 1934 have almost certainly left no successors.

*Leaves* elliptic to oblong or ovate, 3–9 cm. long, 1.5–3.5 cm. broad, rounded at the apex, gradually narrowed into the winged petiole subequal to the blade, dentate or dentate-lobulate at the margin, with no evident farina but with numerous glands on both surfaces. *Scape* 10–20 cm. high, farinose or almost efarinose, bearing a compact head of 6–12 flowers; bracts 5–6 mm. long, lanceolate. *Calyx* cup-shaped, 7–8 mm. long, farinose within and without, divided unequally into oblong or suborbicular lobes, entire or toothed. *Corolla* funnel-shaped, 1.5 cm. long, about 1 cm. across, ivory-white and without an eye, minutely farinose outside; cylindric part of the tube a little longer than the calyx; lobes broadly rounded, connivent, 3.5–4 mm. long, irregularly notched. *Short-styled flowers*: stamens inserted at the mouth of the cylinder, style about 1 mm. long. *Long-styled flowers*: stamens inserted at the middle of the cylinder, style reaching its mouth. *Capsule* globose, enclosed in the calyx.

BHUTAN. Narim Thang, Kurted, *Cooper* 4236—*type*: *Ludlow & Sherriff* 476: Singhi, Kurted, *Cooper* 4975—*type* of *P. Harroviana*.

SE. TIBET. Cha La, Donkar, *Ludlow & Sherriff* 848.

P. FEA *Ward* in Notes Roy. Bot. Gard. Edinb. xv, p. 302 (1927): W. W. Sm. & Forrest, *ibid.* xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929).

This graceful dwarf species was found in 1926 by Ward on the Burma-Tibet Frontier at an altitude of 4700–5000 m. It was growing embedded in moss or lichen in the crevices of almost bare granite cliffs. Its nearest ally is *P. sapphirina*, from which it is readily distinguished by the larger corolla with subentire lobes. The type is in the Kew Herbarium. The plant has not been collected again nor has it been in cultivation.

*Leaves* in small rosettes, about 10 mm. long, spatulate to oblanceolate, obtuse at the apex, tapering into the winged petiole which is subequal to the blade, pinnatifid-dentate, sparingly white-pilose above. *Scape* filiform, 2–3 cm. high, bearing 1–2 nodding sessile flowers; bracts 1–2 mm. long, linear, lanceolate or oblong. *Calyx* 3–4 mm. long, cup-shaped, almost black-purple, minutely farinose, divided to the middle or a little further into 5 irregular oblong lobes, obtuse or acute and entire or denticulate at the apex. *Corolla* 8–10 mm. long, campanulate, blue in the bud and mauve when open, with a crimson tube; cylindric base 3–4 mm. long, gradually widening above into the limb, 7–10 mm. wide, divided into ovate entire or irregularly incised lobes, 4 mm. long. *Short-styled flowers*: stamens, with filaments nearly 1 mm. long, inserted 4 mm. above the base of the corolla; style 5 mm. long, just exceeding the tips of the anthers. *Capsule* globose, equalling the calyx.

BURMA-TIBET FRONTIER. Seing-hku, *Ward* 7020—*co-type*.

*P. FLABELLIFERA* W. W. Sm. in Notes Roy. Bot. Gard. Edinb. XIX, p. 169 (1936).

This dwarf species is known only from the district of Tsari, in SE. Tibet, where it was first collected by Ward in 1935, growing on rocks on alpine grassy slopes at an elevation of 4700–5000 m. Its only near allies are *P. sapphirina* and *P. fea* from which it is readily distinguished by the fan-shaped leaves. Plants raised from seed collected by Ludlow and Sherriff flowered at Edinburgh in April 1939, formed no capsules and are now lost. The type is in the British Museum Herbarium.

*Leaves* 10–12 mm. long, about 5 mm. broad, flabelliform to broadly cuneate, rounded or somewhat flattened at the apex where they are conspicuously dentate (the teeth triangular, apiculate and glandular), elsewhere entire, cuneate at the base with the petiole almost obsolete, faintly farinose below. *Scape* at most 4 cm. high, filiform, bearing 2–4 more or less nodding flowers; bracts 1–2 mm. long, linear to narrow-oblong, fleshy, minutely farinose. *Calyx* about 3 mm. long, cup-shaped, green to almost black, divided to the middle into 5 lanceolate to oblong lobes which are entire or sometimes 2–3-toothed. *Corolla* 8–10 mm. long, campanulate, violet; tube gradually broadening upwards; limb divided into 5 oblong to obovate lobes, 3 mm. long, entire or faintly toothed at the apex. *Long-styled flowers*: style 4 mm. long; stamens inserted 2 mm. above the base of the corolla-tube. *Capsule* globose, scarcely exserted from the calyx.

SE. TIBET. Tsari, above Migyitun, Ward 11949—*co-type*: Ludlow & Sherriff 1737: Tama La, Ludlow & Sherriff 2184.

*P. JIGMEDIANA* W. W. Sm. in Notes Roy. Bot. Gard. Edinb. XIX, p. 171 (1936).

This species is the one aberrant member of the section. It deviates in the pedicelled solitary flower, in the patent corolla-limb and in the development of an annulus. The only alternative section would be *Minutissimae* with which it appears to have even less in common. In facies it strongly suggests association with *P. fea* and *P. sapphirina*. It was collected in Bhutan in 1933 on one occasion only by Sherriff and Ludlow, growing on rocky hillsides at 4700 m. Plants raised from seed flowered at Edinburgh and at Bodnant in May 1936 but have not survived. The type is in the British Museum Herbarium.

*Leaves* in compact rosettes, 8–10 mm. long, spatulate to oblanceolate, rounded or obtuse at the apex, tapering into the winged petiole which in length equals the blade, bluntly dentate at the margin, glabrous, efarinose. *Scape* 2–4 cm. tall, filiform, with a single nodding or suberect flower; bract about 2 mm. long, solitary, linear; pedicel 3–4 mm. long, obscurely farinose at apex. *Calyx* 3 mm. long, cup-shaped, green or blackish green, sometimes faintly farinose, divided to the middle into 5 ovate-oblong obtuse lobes. *Corolla* about 8 mm. long, funnel-shaped, mauve-blue; tube 3–5 mm. long, with a distinct wine-purple annulus; limb 9–10 mm. across, widely patent, divided into narrowly obovate deeply emarginate lobes, 4 mm. long. *Short-styled flowers*: style 1.5 mm. long, anthers reaching the annulus. *Long-styled flowers*: style slightly exceeding the annulus, stamens inserted at middle of the tube. *Capsule* equalling the calyx or slightly longer.

BHUTAN. On the Me La, Ludlow & Sherriff 397—*co-type*.

*P. LUDLOWII* W. W. Sm. in Notes Roy. Bot. Gard. Edinb. XIX, p. 172 (1936).

This species was collected by Sherriff in June 1934 in SE. Bhutan, growing in wet moss on overhanging cliffs at an elevation of 1700 m. On the same date and in the same locality he found *P. Sherriffiae*, its near ally, and of neither of them is there any further record. In the section they are readily distinguished by the very elongate corolla-tube. *P. Ludlowii* looks like a dwarf state of the other species, but differs in the obsolete scape, solitary flower, efarinose corolla and pilose corolla-tube. The type specimen is in the British Museum Herbarium. A single plant, brought to Edinburgh by Sherriff, flowered in 1936, but did not survive.

*Leaves* in small tufts, 3-5 in number, 1.5-3 cm. long, 1-1.5 cm. broad, more or less elliptic, rounded at the apex, abruptly contracted into the hairy petioles 0.5-1 cm. long, irregularly dentate, with numerous white septate hairs above, on the margins and on the midrib below. *Scape* obsolete. *Flower* solitary, sessile, about 2.5 cm. long. *Calyx* cup-shaped, 4 mm. long, 3 mm. broad, divided to one-third into ovate lobes. *Corolla* pale violet, efarinose, thinly pilose within and without, funnel-shaped with a slender cylindrical tube about 1.8 cm. long and a concave limb divided into suborbicular entire lobes 5 mm. in diameter. *Stamens* inserted near apex of corolla-tube.

SE. BHUTAN. At Chungkar, Diwangiri-Trashigong Road, *Ludlow & Sherriff* 554—*co-type*.

*P. NUTANS* *Delavay ex Franch.* in Bull. Soc. Bot. Fr. xxxiii, p. 69 (1886): Pax in Engl. Bot. Jahrb. x, p. 193 (1889): Forbes & Hemsl. in Journ. Linn. Soc. Lond., Bot. xxvi, p. 40 (1889): Pax in Engl. Pflanzenr. Primulaceae, p. 94 (1905): Balf. f. in Journ. Roy. Hort. Soc. Lond. xxxix, p. 153 (1913): Gard. Chron. ser. 3, LIX, p. 225, fig. 110 on p. 162 (1916): Forrest in The Garden, LXXX, fig. p. 298 (1917): Hutchinson in Bot. Mag. t. 8735 (1917): W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37, fig. 39 (1929): Bull. Alp. Gard. Soc. II, pp. 58, 320, fig. facing p. 323 (1934): *ibid.* III, pp. 57, 91, 98, fig. p. 96 (1935). *P. penduliflora* Franch. ex Petitmengin in Le Monde des Plantes, no. 49, p. 6 (1908).

This very fine species was discovered by Abbé Delavay in 1884 at Mao-kou-tchong, a plateau between Langkong and Hoking, at an elevation of 3500 m., growing in open pine forests and rocky pastures. The type, *Delavay* 53, is in the Paris Herbarium. The collections of Forrest from 1904 onwards showed that the plant has a wide but not continuous distribution in the ranges of western Yunnan. It is recorded from within the borders of SW. Szechwan and somewhat unexpectedly from eastern Yunnan. Its allies are *P. spicata* Franch. and *P. siamensis* Craib. All three have a strong tendency to spicate inflorescences, but may produce capitula especially if the number of flowers is few. *P. penduliflora* Franch. ex Petitmengin was described from dwarf plants under *Delavay* 3826. Similar specimens collected by Forrest on cliff ledges are clearly referable to *P. nutans*.

Seed secured by Forrest in 1914 produced flowering plants in 1916 with Mr J. C. Williams, Caerhays, Cornwall. Of all the members of the section *P. nutans* is the most amenable in culture and sets seed in the open in favourable seasons, but is monocarpic.

*Leaves* narrowly elliptic to broadly oblanceolate, 5-20 cm. long, 2-5 cm. broad, rounded or obtuse at the apex, gradually narrowed into the winged petiole equalling one-half to one-third of the blade, repand-denticulate, efarinose, with numerous multicellular hairs on both surfaces, particularly on the midrib below. *Scape* 10-50 cm. high, farinose towards the apex, bearing a dense head or a compact spike 2-5 cm. long, with 5-15 nodding flowers, bracts small, linear or lanceolate, farinose. *Calyx* broadly campanulate, 5-6 mm. long, farinose especially within, divided to about the middle into ovate acute lobes. *Corolla* funnel-shaped, 2-2.5 cm. long, lavender-blue to violet, farinose; lower constricted part of the tube about 1 cm. long, limb 2-2.5 cm. across, divided into ovate or suborbicular lobes, sometimes entire but usually shortly emarginate with often a mucro in the notch. *Long-styled flowers*: stamens inserted 3 mm. above the base of the tube; style 7-9 mm. long. *Short-styled flowers*: stamens inserted at the top of the constricted part of the tube; style 1.5 mm. long. *Capsule* subglobose, included in the calyx.

YUNNAN. Pass from Teng-chuan to Sung-kwei, *Forrest* 72: Yung-pe mountains, *Forrest* 10901, 11029, 15551, 16600, 16862, 20675, 30184: western flank of the Tali Range, *Forrest* 11574, 11595, 11596: Ghi Shan, east of Tali Lake, *Forrest* 13524: mountains of Ming-hua, south of Tali, *Forrest* 13510, 13523: Ma-eul-chan, *Delavay* 3826—*co-type* of *P. penduliflora*: Pin-chuan Hsien, *Tsai* 52964: Kiao-me-ti, *E. E. Maire*: Ie-ma-tchouan, *E. E. Maire*: Tong-tchouan, *E. E. Maire*: *Ducloux* 884.

SECHWAN. Mountains east of Yung-ning, *Forrest* 21591: mountains south-east of Muli, *Forrest* 22160, 22410: *Handel-Mazzetti* 5214.

P. REIDII *Duthie* in Report Saharanpur Bot. Gard. 1885, p. 30: in Gard. Chron. N.S. xxv, p. 277 (1886) in nota, and xxvi, p. 691, fig. 136 (1886): Hook. f. in Bot. Mag. t. 6961 (1887): Journ. Hort. ser. 3, xv, p. 52 (1887): *ibid.* xxvi, p. 442 (1893): Journ. Roy. Hort. Soc. Lond. xvi, Proc. p. lxxv, fig. 23 (1894): Pax in Engl. Pflanzenr. Primulaceae, p. 67 (1905): Journ. Roy. Hort. Soc. Lond. xxxix, pp. 153, 185, 187, 200, 207, 220, fig. 90 (1913): Harrow in The Garden, lxxvii, p. 231, with fig. (1913): *ibid.* lxxx, fig. on p. 229 (1916): *ibid.* lxxxiii, fig. on p. 164 (1919): Farrer, English Rock-Gard. II, p. 174, pl. 20 (1919): W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. liv, p. 37, fig. 65 (1929): Bull. Alp. Gard. Soc. II, pp. 167, 320, fig. facing p. 146 (1934).

This beautiful species was secured by Duthie in 1883 in Garhwal and in 1884 in Kumaon at an altitude of 4000–4300 m., growing on wet rocks near a glacier. In his diagnosis Duthie mentions an earlier finding, represented in the Calcutta Herbarium by specimens labelled 'Tihri Garhwal, 1869', but without name of collector. Its nearest allies are *P. eburnea* and *P. Wigramiana*. From the former it is easily separated by the very hairy leaves; from the latter it diverges in the more glandular calyx, in the emarginate but not toothed corolla-lobes and in the possession of an annulus. The type, *Duthie* 3133, is in the Dehra Dun Herbarium. Seeds taken from Duthie's herbarium specimens produced plants which flowered at Kew in May 1887. Since that time it has been frequently but not continuously in cultivation. It sets seed occasionally in culture, but requires very careful treatment and is always rare.

*Leaves* oblong to oblong-lanceolate, 5–20 cm. long, 2–3 cm. broad, obtuse or rounded at the apex, gradually narrowed into the slightly winged petiole only a little shorter than the blade, lobulate-dentate to coarsely crenate, efarinose, with long multicellular hairs on both surfaces. *Scape* 6–15 cm. tall, farinose towards the apex, bearing a compact head of 3–10 pendent flowers; bracts 1–2 mm. long. *Calyx* broadly campanulate, 6–9 mm. long, farinose within, sparingly so without, divided to the middle into ovate to subrotund lobes, glandular-ciliate and often apiculate. *Corolla* ivory-white, 1.8–2.2 cm. long and broad; tube 9–10 mm. long, abruptly dilated into the almost globular limb; lobes broadly oblong or ovate, connivent, emarginate, with or without a tooth in the notch. *Long-styled flowers* stamens inserted at the middle of the tube; style about 5 mm. long. *Capsule* globose, included in the calyx.

NW. HIMALAYA. Drati Pass, Chamba, *Lace* 1990: Pan Satch, Kulu, *Cooper* 5136.

P. SANDEMANIANA W. W. Sm. in Notes Roy. Bot. Gard. Edinb. xix, p. 314 (1938). *P. sp. aff. Cawdoriana* Ward in *ibid.* xix, p. 219 (1937).

This striking species was found by Ludlow and Sherriff in 1936 at Migyitun in the Tibetan province of Tsari, at an altitude of 3800 m. The specimens collected were in very immature flower or in advanced fruit and were referred provisionally to the proximity of *P. Cawdoriana* Ward. But plants raised from seed came into flower at Edinburgh in 1938 and revealed a new species akin to *P. Wattii* King and *P. chasmophila* Balf. f. It differs from both in the farinose scape and in the form of the corolla. More remote is *P. Wollastonii* Balf. f. with a campanulate corolla and entire lobes. A further supply of seed permitted *P. Sandemaniana* to remain in cultivation until 1940, but it is now lost.

*Leaves* arranged in a compact rosette, elliptic to oblanceolate, 4–8 cm. long, 2–3 cm. broad, obtuse or rounded at the apex, tapering into a winged petiole 1–2 cm. long, irregularly and sometimes remotely dentate-lobulate, efarinose, with numerous white multicellular hairs on both surfaces and on the margin. *Scape* 8–11 cm. high, everywhere more or less farinose, but without hairs, bearing a compact head of 3–5 pendent flowers;

bracts 1-4 mm. long, ovate to elliptic, sprinkled with farina. *Calyx* cupular, 7-10 mm. long, farinose especially within, divided to one-third into subquadrate or semi-orbicular lobes, entire or toothed. *Corolla* widely funnel-shaped, 1.75-2 cm. long, 2-3 cm. broad at apex, bluish purple; tube almost twice as long as the calyx, lightly farinose; lobes rounded or broadly ovate, shortly and narrowly emarginate, farinose within. *Short-styled flowers*: stamens inserted at the throat of the cylindrical part of the corolla-tube; style reaching to one-third of the cylinder. *Long-styled flowers*: stamens inserted about the middle, style slightly exceeding the cylinder.

SE. TIBET. Migyitun, Tsari, *Ludlow & Sherriff* 1708, 2118, 2796—cult. type.

*P. SAPPHEIRINA* Hook. f. & Thoms. ex Hook. f. in Fl. Brit. Ind. III, p. 492 (1882): Watt in Journ. Linn. Soc. Lond., Bot. XX, p. 10, t. 13C (1882) and in Gard. Chron. XXI, p. 542, with fig. on p. 545 (1884): Hook. f. in Bot. Mag. t. 6961 (1887): Pax in Engl. Bot. Jahrb. x, p. 188 (1889) and in Engl. Pflanzenr. Primulaceae, p. 69, fig. 24D (1905): Watt in Journ. Roy. Hort. Soc. Lond. XXIX, pp. 198, 302, 306, 307 (1904): Balf. f., ibid. XXXIX, p. 153 (1913): W. W. Sm. & Forrest, ibid. LIV, p. 37, fig. 38 (1929) and in Notes Roy. Bot. Gard. Edinb. XVI, p. 40 (1928).

This very dwarf species was discovered by Hooker in 1849 in his exploration of the Sikkim Himalaya. It grows on damp rocky ground, on grassy rock-ledges and sometimes on mossy boulders at elevations of 4000-5000 m. It is not uncommon in Sikkim and extends into Bhutan and the adjoining parts of Tibet. The very small corolla distinguishes it readily from all the other members of the section. It flowered for the first time in cultivation at Kew in 1887 and on several occasions since from fresh importations of seed, but is very short-lived. The type material, *Hooker* 32, is in the Kew Herbarium.

*Leaves* 5-10 mm. long, 2-5 mm. broad, oblanceolate to obovate, tapering into a short but broad petiole, coarsely pinnatifid-dentate, with scattered short white hairs above and sometimes finely glandular. *Scape* at most 5 cm. high, filiform, bearing 1-4 semi-pendent flowers; bracts 1-2 mm. long, narrowly ovate. *Calyx* 2-3 mm. long, cup-shaped, black-purple, cut to about the middle into 5 oblong obtuse lobes. *Corolla* 4-5 mm. long, funnel-shaped, minutely pubescent, violet-purple to blue; tube very short; limb 5-6 mm. across, divided into bi-lobulate ovate lobes, 2.5 mm. long, 3 mm. broad. *Long-styled flowers*: styles 3 mm. long, stamens inserted 1.5 mm. above the base of the corolla-tube. *Capsule* subglobose, included.

SIKKIM. Dza-lep La, *King's collector* 4384A: Cho La, in 1882, *King's collector*: Kapoor, near Kinchinjunga, in 1887, *King's collector*: Kangla, in 1888, *King's collector*: Kapoor, Ribu & Rhomoo 23: *Cooper* 795: Changu, *Cooper* 35: *Lowndes* 601: Pongling, Rhomoo 916.

BHUTAN. Narim Thang, *Cooper* 4265: Me La, *Ludlow & Sherriff* 391: Tang Chu, Ritang, *Ludlow & Sherriff* 3204: Dunshinggang, Central Bhutan, *Ludlow & Sherriff* 3304.

S. TIBET. Chumbi, *Bailey* 29: Milakatong, near Tawang, *Ludlow & Sherriff* 666.

*P. SHERRIFFIAE* W. W. Sm. in New Flora and Silva, XVIII, p. 130, cum ic. (1936): in Gard. Chron. ser. 3, xcvi, p. 312, fig. 124 (1935): ibid. xcix, p. 239 (1936): in Journ. Roy. Hort. Soc. Lond. XL, Proc. p. clxvi (1935): ibid. Lxi, pp. 257, 263 and Proc. pp. xcvi, cxxxvii (1936): in Bot. Mag. t. 9494 (1938): in Gard. Chron. ser. 3, ciii, p. 351, fig. 140 (1938).

This remarkable species is known only from Chungkar in SE. Bhutan, where it was discovered in June 1934 by Captain George Sherriff on cliffs at an altitude of 1700 m. In habit and in foliage it shows kinship with *P. nutans* Franch., but is conspicuous in its section by the very elongate corolla-tube. The type specimen is in the British Museum Herbarium. A plant was brought to Edinburgh by Sherriff in June 1935 and flowered there in July. Seed forwarded earlier germinated well and plants raised by Mr T. Hay

and shown to the Royal Horticultural Society gained a Preliminary Commendation in September 1935 and an Award of Merit in April 1936. It is not hardy out-of-doors, but is amenable to pot-culture in a cool house and can be regarded as established.

*Leaves* in a flat rosette, efarinose, 6–17 cm. long, 2.5–5 cm. broad, usually oblanceolate, but sometimes subovate or elliptic, rounded at the apex, narrowed into winged petioles 1–2.5 cm. long, entire or remotely toothed, fringed with white multicellular hairs, slightly pilose above, more copiously so below especially on the midrib and veins. *Scape* 4–10 cm. tall, glabrous, sparingly farinose, bearing a compact head of 2–7 flowers which are almost horizontal and are supported by small lanceolate to oblong bracts. *Calyx* cupular, about 1 cm. long, slightly farinose without, markedly farinose within, divided to at least one-third into narrowly ovate lobes. *Corolla* pale violet with a white edge and well flecked with farina outside and at the throat inside, shaped like a very long funnel, about 5 cm. long, 2–3 cm. broad at the expanded limb; tube slenderly cylindric and slightly curved, 3.5–4 cm. long, 1.5–2 mm. broad, dilated only near the apex; lobes almost suborbicular, about 1 cm. in diameter. *Flowers* monomorphic: stamens about 4 mm. long, inserted at the middle of the short inflated upper portion of the tube; style shortly exceeding the tips of the anthers. *Capsule* globular, 7–8 mm. in diameter, opening by broadly triangular teeth.

SE. BHUTAN. Chungkar, Diwangiri-Trashigong Road, *Ludlow & Sherriff 552—co-type.*

*P. SIAMENSIS* Craib in Kew Bull. 1922, p. 238: Craib in Gard. Chron. ser. 3, LXXXV, p. 89, fig. 35 (1924) and in Journ. Roy. Hort. Soc. Lond. I, Proc. p. ci (1925): Stapf in Bot. Mag. t. 9100 (1926): W. W. Sm. & Forrest in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929) and in Notes Roy. Bot. Gard. Edinb. xvi, p. 40 (1928): Fletcher in (Craib) Fl. Siam. Enum. II, p. 322 (1938).

Discovered by Dr A. F. G. Kerr in 1921 growing in the crevices of limestone mountains in the upper Meping Valley, north of Chiangmai in the Siamese Shan States, at an elevation of 1700–2000 m. Its nearest ally is *P. spicata* Franch. from which it differs in the more robust habit, in the subentire leaves and in the shape of the corolla-lobes. *P. nutans* Delavay, also akin, has a more congested inflorescence and rounded corolla-lobes. The type is in the Kew Herbarium. The first plants to flower in cultivation were raised in the Cruickshank Botanic Garden at Aberdeen in 1924. This introduction and one in 1932 failed to produce ripe capsules and the period of culture was very brief.

*Leaves* oblanceolate to elliptic-oblong, 6–12 cm. long, 2–4 cm. broad, rounded at the apex, gradually narrowed into the winged petiole 2–7 cm. long, slightly wavy and ciliolate, efarinose, with numerous multicellular hairs on both surfaces. *Scape* about 15 cm. tall, farinose, bearing a loose elongate spike of 4–8 semi-pendent flowers; bracts linear to lanceolate, 4 mm. long. *Calyx* more or less ellipsoid, 6–8 mm. long, often copiously farinose, divided to about the middle into ovate acute lobes. *Corolla* funnel-shaped, pale violet, 2–2.5 cm. long, finely farinose without and at the mouth within; cylindrical basal portion of the tube 1 cm. long; lobes broadly elliptic to ovate-elliptic, 9 mm. long, 6–8 mm. broad, entire or 2–4-dentate at the apex. *Short-styled flowers*: stamens inserted 5–7 mm. above the base of the corolla-tube; style 1.5 mm. long. *Long-styled flowers*: stamens inserted 3 mm. above the base; style 6 mm. long.

SIAM. Doi Chiang Dao, *Kerr 5582—co-type.*

*P. SIPHONANTHA* W. W. Sm. in Notes Roy. Bot. Gard. Edinb. xv, p. 303 (1927): W. W. Sm. & Forrest, *ibid.* xvi, p. 40 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929).

This species is known only from the Seing-hku Valley on the Burma-Tibet Frontier, where it was found by Ward in 1926 at 3500–3800 m., growing on exposed earthy slopes or sometimes under the shelter of boulders. It differs from its near ally *P. Caudoriana*

Ward in the longer leaves and much smaller flowers. The type is in the British Museum Herbarium. Seeds were collected, but there is no record of it in cultivation.

*Leaves* oblanceolate, 3.5–6.5 cm. long, 1–1.5 cm. broad, obtuse to subacute at the apex, tapering into the winged petiole 0.5–2.5 cm. long, irregularly sinuate-denticulate, minutely scabrid on both sides, with long white hairs on the midrib below. *Scape* 12–25 cm. tall, thinly covered with minute hairs, slightly farinose towards the apex, bearing an umbel of 4–6 deflexed flowers; bracts subrotund, farinose within, forming an apical crown. *Calyx* cup-shaped, about 3.5 mm. long, farinose especially within, divided to the middle into subequal ovate or rotund-oblong lobes. *Corolla* pale violet, 1.7 cm. long, elongate; tube constricted at base for 3–4 mm., gradually widening into the limb; lobes narrow-oblong, 3 mm. long, shortly 2–3-incised-dentate at the apex. *Long-styled flowers*: stamens inserted about 3 mm. from base of corolla; style slightly exceeding the anthers. *Capsule* subglobose, 3–4 mm. in diameter.

BURMA-TIBET FRONTIER. Valley of the Seing-hku, *Ward* 7228—*co-type*, 7040, 7551.

*P. SOLDANELLOIDES* *Watt* in Journ. Linn. Soc. Lond., Bot. xx, p. 10, t. 11C (1882): Hook. f. in Fl. Brit. Ind. iii, p. 493 (1882): Pax in Engl. Bot. Jahrb. x, p. 188 (1889) and in Engl. Pflanzenr. Primulaceae, p. 69, fig. 24C (1905): Watt in Journ. Roy. Hort. Soc. Lond. xxix, p. 309, fig. 70 (1904): Balf. f. ibid. xxxix, p. 153 (1913): Craib, ibid. xxxix, p. 187 (1913): W. W. Sm. & Forrest, ibid. lrv, p. 36 (1929) and in Notes Roy. Bot. Gard. Edinb. xvi, p. 41 (1928).

Discovered by Hooker in 1849 on the Kankola Pass, this species is not uncommon at elevations of 4300–5000 m. in the Sikkim Himalaya and extends into Bhutan and the Chumbi Valley, Tibet. Among the dwarf species of the section it can be recognized by the glabrous leaves, by the 1-flowered ebracteate scape and by the large white corolla. The type material, *Hooker* 30, is in the Kew Herbarium. There is no record of its flowering in cultivation.

*Leaves* 8–15 mm. long, 2–5 mm. broad, ovate, deeply pinnatifid, obtuse at the apex, tapering into petioles as long or up to twice as long as the blade, glabrous, efarinose. *Scape* 2.5–4 cm. high, filiform, ebracteate, carrying a solitary nodding flower. *Calyx* 4.5 mm. long, campanulate, dull blackish-green, glabrous, divided to the middle into triangular to ovate acute lobes. *Corolla* 10–15 mm. long, broadly campanulate, glistening white; short cylindric base of tube widening gradually upwards; limb 10–15 mm. across, divided into oblong-obovate lobes 3–5 mm. long, emarginate or erose at the apex. *Long-styled flowers*: style 2.5 mm. long; stamens, with filaments 0.5 mm. long, inserted 1.5 mm. above the base of the corolla.

SIKKIM HIMALAYA. Patang La, *King's collector* 4384: Jongri, in 1887, *King's collector*: Lampokri, *Rhomoo* 886.

BHUTAN. Me La, *Ludlow & Sherriff* 878: Changsethang, *Ludlow & Sherriff* 3406.

*P. SPICATA* *Franch.* in Bull. Soc. Bot. Fr. xxxii, p. 269 (1885): Pax in Engl. Bot. Jahrb. x, p. 187 (1889): Forbes & Hemsl. in Journ. Linn. Soc. Lond., Bot. xxvi, p. 43 (1889): Pax in Engl. Pflanzenr. Primulaceae, p. 70 (1905): Balf. f. in Journ. Roy. Hort. Soc. Lond. xxxix, p. 153, fig. 58 (1913): Irving in Gard. Chron. ser. 3, LXIV, fig. 14 (1918): Hutchinson in Bot. Mag. t. 8821 (1919): W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 41 (1928) and in Journ. Roy. Hort. Soc. Lond. lrv, p. 37 (1929). *P. delicata* Forrest in Notes Roy. Bot. Gard. Edinb. iv, p. 222, pl. xxix B (1908). *P. delicatula* Dunn in Journ. Linn. Soc. Lond., Bot. xxxix, p. 480 (1911).

This very graceful species was discovered by Abbé Delavay in 1884 on Mount Tsangchan near Tali, growing on stony meadows and cliff ledges at an elevation of 3000–3700 m. The type, *Delavay* 109, is in the Paris Herbarium. Apparently the plant was not seen



again until Forrest collected it on various occasions from 1906 onwards but never outside the Tali district. Its nearest ally is *P. siamensis* Craib which has a similar interrupted spike of flowers. *P. delicata* loc. cit. is only a depauperated state of *P. spicata* and *P. delicatula* loc. cit. an alternative as Forrest's specific name was preoccupied. *P. spicata* was introduced into cultivation in 1908 by Mr A. K. Bulley, for whom Forrest was collecting, but was soon lost. Plants from a second consignment of seed came into flower in 1918 and when exhibited by Messrs R. Wallace of Colchester gained an Award of Merit from the Royal Horticultural Society. In culture no ripe capsules are produced and plants, easily raised from native seed, usually die after flowering.

*Leaves* oblong-elliptic to obovate-elliptic, 1.5–8 cm. long, 1–2.5 cm. broad, obtuse or rounded at the apex, gradually narrowed into a petiole 1–3 cm. long, doubly serrate-crenate, efarinose, with numerous multicellular hairs on both surfaces. *Scape* 5–20 cm. high, slender and flexuous, farinose at the apex, bearing usually 3–8 flowers in a lax subunilateral spike, occasionally 1–2 only; bracts linear or oblong, 3–4 mm. long. *Calyx* widely campanulate, 5 mm. long, finely farinose without, copiously within, irregularly cut to the middle into ovate lobes, entire or toothed at the apex. *Corolla* funnel-shaped, 1.5–2 cm. long, bright blue, sparingly and minutely puberulous; cylindrical part of tube 5–8 mm. long; limb reaching 2 cm. across, divided into ovate to elliptic lobes deeply emarginate and often with a mucro in the notch. *Short-styled flowers*: stamens inserted near the mouth of the cylinder; style 1 mm. long. *Long-styled flowers*: stamens inserted in the lower half of the cylinder; style 5–6 mm. long. *Capsule* subglobose, not exerted from the calyx.

YUNNAN. Tali Range, *Forrest* 1804, 1807, 6802, 11598, 15477, 30188: *Tsai* 53934: Ghi Shan, east of Tali Lake, *Forrest* 13506: Ming-hua mountains, south of Tali, *Forrest* 13530.

*P. umbratilis* Balf. f. & Cooper in Notes Roy. Bot. Gard. Edinb. xiii, p. 22 (1920): W. W. Sm. & Forrest, *ibid.* xvi, p. 41 (1928) and in Journ. Roy. Hort. Soc. Lond. lrv, p. 37 (1929): Cooper in Notes Roy. Bot. Gard. Edinb. xviii, pp. 94, 102, 105, 106, 110 (1933). *P. metria* Balf. f. & Cooper, *ibid.* xiii, p. 13 (1920).

*P. umbratilis* is known only from Bhutan, where Cooper in 1914 found it growing on grassy ledges of dry rocks at 3700 m. In habit it recalls *P. Buryana* Balf. f. and has the same hairy scape, but lacks the shaggy calyx and bracts of that species. Plants raised from seed of *Cooper* 4787 flowered at Edinburgh in 1918 and persisted for a few years. A white variety, described below, was discovered by Ludlow and Sherrieff; plants under their number 3384 came into flower at Edinburgh in 1939 and yielded a few seeds.

*Leaves* 5–10 cm. long, 1–2 cm. broad, oblong to subelliptic, rounded at the apex, narrowed into a winged petiole subequal to the blade, dentate-lobulate, shaggy with articulated hairs on both surfaces. *Scape* 8–12 cm. long, thinly hirsute, efarinose, bearing a compact head of 5–6 deflexed flowers; bracts 4–5 mm. long, ligulate, green, glabrous. *Calyx* cup-shaped, 4–5 mm. long, glabrous without, slightly farinose within, divided to about the middle into elliptic-ovate glandular-ciliate lobes. *Corolla* funnel-shaped, about 1.5 cm. long, pale purple, rarely white; constricted part of tube 7–8 mm. long; lobes 4 mm. long, rounded, emarginate, obscurely denticulate. *Short-styled flowers*: stamens inserted near the mouth of the constricted part of the corolla-tube; style half the length of this tube. *Capsule* not exceeding the calyx, dehiscing by apical valves.

BHUTAN. Kurmathang, Pumthang, *Cooper* 2134—*type*: Champa, Pumthang, *Cooper* 3995, 4011, 4042—*type* of *P. metria*, 4787: Tsamba, *Bailey*: Thampe La, *Ludlow & Sherrieff* 3394.

var. *alba* Fletcher, var. nov.; a planta typica floribus albis, stylis longioribus differt.

BHUTAN. Rinchen Chu, *Ludlow & Sherrieff* 3384—*type* of var., 3444.

*P. UNIFLORA* Klatt in Linnaea, xxxvii, p. 500 (1872): Watt in Journ. Linn. Soc. Lond., Bot. xx, t. 11 (1882): Hook. f. in Fl. Brit. Ind. iii, p. 492 (1882): Gard. Chron. xxi, p. 542, fig. on p. 545 (1884): Pax in Engl. Bot. Jahrb. x, p. 187 (1889) and in Engl. Pflanzenr. Primulaceae, p. 67, fig. 24B (1905): Watt in Journ. Roy. Hort. Soc. Lond. xxix, p. 309, fig. 70 (1904): Balf. f., ibid. xxxix, pp. 153, 165 (1913): Craib, ibid. xxxix, p. 187, fig. 91 (1913): Gard. Chron. ser. 3, LI, p. 407, fig. 194 (1912): W. W. Sm. & Forrest in Notes Roy. Bot. Gard. Edinb. xvi, p. 41 (1928) and in Journ. Roy. Hort. Soc. Lond. LIV, p. 37 (1929).

This beautiful species was first collected in 1848 by Hooker on the Kankola Pass in Sikkim at an elevation of 4300–4700 m. It occurs sporadically in the northern and eastern parts of the Sikkim Himalaya and extends into Bhutan and the Chumbi Valley in Tibet. The type, *Hooker* 31, is in the Kew Herbarium. As with *P. soldanelloides* Watt, the plant has a corolla larger than its rosette of leaves and both are readily distinguished in the section by that character. Apart from this resemblance the two are not closely akin. The only record in cultivation seems to be in 1911–12 when plants flowered at Kew and at Edinburgh, but did not survive.

*Leaves* ovate to spatulate, 1–2 cm. long, 0.5–1 cm. broad, obtuse or acute at the apex, truncate or cuneate at the base, incised-dentate to crenate at the margin, efarinose, with numerous white multicellular hairs on both surfaces; petiole scarcely winged, as long as the blade. *Scape* 5–9 cm. tall, glabrous, efarinose or nearly so, bearing 1–2 large flowers; bracts oblong to subulate, minute. *Calyx* campanulate, deep wine-red, about 8 mm. long, divided sometimes deeply, sometimes slightly, into oblong lobes, apiculate and often undulate-crenate at the apex. *Corolla* very large for the size of the foliage, about 3 cm. in diameter, very open and saucer-shaped, pale blue-violet, wine-red at the base; tube 8–10 mm. long, farinose within; limb divided into deeply emarginate lobes with or without a mucro in the sinus, often toothed as well. *Short-styled flowers*: stamens inserted at the mouth of the cylinder; style barely 2 mm. long.

SIKKIM. Chola, *Gammie* in 1892: Eumtso La, *Smith & Cave* 1297: Chakung, *Smith* 4007: *Cooper* 913.

s. TIBET. To-koo La, Chumbi, *Dungboo* in 1879: between Chola and Chumbi, *Dungboo* in 1882.

BHUTAN. Thita Tso, Rinchen Chu, *Ludlow & Sherrieff* 3438, 3536.

*P. WATTII* King ex Watt in Journ. Linn. Soc. Lond., Bot. xx, p. 10, t. 14A (1882): Hook. f. in Fl. Brit. Ind. iii, p. 672 (1882): Pax in Engl. Bot. Jahrb. x, p. 187 (1889) and in Engl. Pflanzenr. Primulaceae, p. 66 (1905): Gard. Chron. ser. 3, LI, p. 286, t. 138 (1912): Craib in Bot. Mag. t. 8456 (1912): Watt in Journ. Roy. Hort. Soc. Lond. xxix, pp. 298, 307, fig. p. 309 (1904): Balf. f., ibid. xxxix, p. 153 (1913): Craib, ibid. xxxix, p. 187, fig. 94 (1913): W. W. Sm. & Forrest, ibid. LIV, p. 37 (1929) and in Notes Roy. Bot. Gard. Edinb. xvi, p. 41 (1928).

Discovered by King's Native Collector in 1877 on the Chola Range, this species occurs sporadically in eastern Sikkim on steep banks and ridges at an altitude of 4300–4600 m. From the species in its section with purple or violet flowers it is readily separated by the glabrous efarinose scape, by the much cut lobes of both calyx and corolla and by the almost efarinose inflorescence. The type is in the Kew Herbarium. Seeds collected by Smith in Sikkim in 1910 produced flowering plants at Kew and Edinburgh in 1912. It has been re-introduced from time to time but is short-lived and rarely ripens seed under cultivation.

*Leaves* oblong to oblanceolate, 5–10 cm. long, 1.5–2 cm. broad, obtuse at the apex, narrowed into a slightly winged petiole subequal to the blade, lobulate-dentate to coarsely crenate, with long multicellular hairs on both surfaces, efarinose. *Scape* 10–18 cm. high, bearing a compact head of 5–10 flowers; bracts small, lanceolate or almost round. *Calyx*

cupular, 8–10 mm. long, divided unequally to about the middle into oblong lobes, irregularly toothed. *Corolla* widely campanulate, violet with a white farinose eye, about 1.5 cm. long, as broad at apex; constricted part of the tube 5–6 mm. long; lobes obovate, conspicuously and irregularly toothed, sometimes almost fringed. *Short-styled flowers*: stamens inserted at the mouth of the cylindrical part of the tube; style 2 mm. long. *Capsule* subglobose, equalling the calyx.

SIKKIM. Natong, Chola Range, *King's Collector* 4480—*co-type*: Yak La, *Gammie* 1379: *Chamnagc*, *Cooper* 276, 853: *Changu*, *Cave* 6990.

ASSAM HIMALAYA. *Ward* 13690.

BURMA-TIBET FRONTIER. Seing-hku Wang, *Ward* 7017.

P. WIGRAMIANA *W. W. Sm.* in *Notes Roy. Bot. Gard. Edinb.* xviii, p. 182 (1934): *Gard. Chron.* ser. 3, xcv, p. 300, fig. 145 (1934): *Journ. Roy. Hort. Soc. Lond.* lxx, pp. 402, 461 (1934): *W. W. Sm.* in *Bot. Mag.* t. 9451 (1936): *Bull. Alp. Gard. Soc.* iv, pp. 252, 272, 281, fig. p. 274 (1936).

This very fine species is known only from the high mountains of Nepal where it was found by Professor K. N. Sharma in 1931 at an elevation of 5700 m. The original description compared it with *P. nutans* Franch. and *P. eburnea* Balf. f. In this review of its section it is now evident that the true affinity is with *P. Reidii* Duthie, from which it differs in the more robust habit and in the larger exannulate corolla with erose lobes. Otherwise the similarity is marked and transitional forms may yet be found. Plants raised from seed collected by Sharma were exhibited in flower in 1934 by Mr T. Hay, gaining an Award of Merit from the Royal Horticultural Society, but neither these nor plants grown in a few other gardens suggested identity with *P. Reidii*. The species is no longer in cultivation except at Bodnant.

*Leaves* forming a spreading rosette, oblanceolate to oblong or ovate, 6–10 cm. long, 2–3.5 cm. broad, rounded at the apex, narrowed into the winged petiole 2–4 cm. long, remotely toothed, with many soft multicellular hairs above and below. *Scape* 20–25 cm. high, farinose above, bearing a compact head of 6–7 pendent flowers; bracts less than half the calyx, lanceolate or oblong. *Calyx* cup-shaped, about 1 cm. long, often unevenly developed, divided to one-third or even to the base on the less developed side, farinose especially within; lobes incised by 2–5 prominent teeth. *Corolla* widely funnel-shaped, about 3 cm. long, slightly farinose without; constricted part of the tube 10–12 mm. long, abruptly expanding into the limb 2.5 cm. across; lobes rounded to ovate, 10 mm. long, usually distinctly toothed, sometimes subentire. *Short-styled flowers*: stamens inserted at the throat of the cylindrical tube. *Long-styled flowers*: stamens inserted about the middle of the tube; style slightly exserted.

NEPAL. Sherkathan, *Sharma* E. 391—*type*: Teengaung, *Sharma* E. 55: Taro Dunga, *Bailey* 66.

P. WOLLASTONII *Balf. f.* in *Kew Bull.* 1922, p. 152: *W. W. Sm. & Forrest* in *Notes Roy. Bot. Gard. Edinb.* xvi, p. 41 (1928) and in *Journ. Roy. Hort. Soc. Lond.* liv, p. 37 (1929): *T. Hay* in *Gard. Chron.* ser. 3, xci, p. 347, t. 156 (1932): *R. Hay* in *Revue Hort.* p. 151, t. 49 (1932): *Journ. Roy. Hort. Soc. Lond.* lviii, Proc. p. xxvii (1933): *Bull. Alp. Gard. Soc.* ii, pp. 58, 320 (1934): *ibid.* iii, pp. 197, 229, fig. p. 231 (1935): *W. W. Sm.* in *Bot. Mag.* t. 9401 (1935).

This species was first collected by Dr A. F. R. Wollaston during the Mount Everest Expedition of 1921, growing at an altitude of 4600–5000 m. both eastwards and westwards from Mount Everest in Tibetan territory. In 1930 it was found by Major Lal Dhwoj on the south side of the Himalaya in East Nepal. His specimens are much more farinose and have smaller corollas than the Tibetan, but appear to be quite conspecific.

The nearest allies are *P. Wattii* King and *P. Sandemaniana* W. W. Sm., from which it is easily separated by the entire lobes of the bell-shaped corolla. The type is in the Kew Herbarium. Seeds collected by Dhwoj were received in this country in 1931 and the resulting plants flowered in April 1932 at Hyde Park. It cannot be depended on to produce seed, but root-cuttings are successfully propagated. The very farinose Nepal plant is still in cultivation in Edinburgh, flowering in 1942 before end of March.

*Leaves* arranged in a flat rosette, oblanceolate to obovate, 2.5–5 cm. long, 1.25–2.5 cm. broad, rounded at the apex, narrowed into the short winged petiole, dentate or crenate or subentire, densely ciliate, with white multicellular hairs on both surfaces, copiously farinose below or efarinose, but secreting glands always present. *Scape* 12–20 cm. high, farinose throughout or only at apex, bearing a head of 2–6 pendent flowers; bracts small, lanceolate. *Calyx* cup-shaped, 5–6 mm. long, greenish to dark purple, often farinose, cut to about one-third into ovate pointed lobes. *Corolla* bell-shaped, 1.8–2.5 cm. long, varying from dark purple to bright blue, very farinose to subefarinose within and without; lower cylindrical part of the tube as long as the calyx, quickly expanding into the limb; lobes broadly ovate, entire, 5 mm. long. *Short-styled flowers*: stamens inserted at the mouth of the constricted portion of the tube; style barely 1 mm. long. *Long-styled flowers*: style about 7 mm. long; stamens inserted at the middle of the basal tube.

S. TIBET. S. Karma Valley, Norton 179.

NEPAL. Tenboozey, Lal Dhwoj 188; Ramding, Sharma E. 462.

The specimens cited in this paper are in the Edinburgh Herbarium.

New Asiatic Primulas. By SIR WILLIAM WRIGHT SMITH, F.L.S. and  
HAROLD ROY FLETCHER, PH.D., D.Sc.

[Read 6 March 1941]

THE new species of *Primula* described here are the result of the examination of a considerable amount of unidentified material very kindly put at our disposal from various herbaria. We are particularly indebted to the Keeper of Botany in the British Museum for the opportunity of examining the *Primulas* collected by Messrs Ludlow, Sherriff and Taylor during their 1938 expedition into south-east Tibet, to the Director of the Royal Botanic Gardens, Kew, and to Dr E. D. Merrill of the Arnold Arboretum for Chinese material in the herbarium of that institution and also in the Gray Herbarium.

***Primula Aliciae*** Taylor ex. W. W. Sm. Species sectionis Souliei atque affinis *P. xanthopae* Balf. f. et Cooper, a qua foliis vix pectinato-incisis haud aureo-farinosi, pedicellis brevioribus, calyce majore inter alia removetur.

*Planta* ad 18 cm. alta, scabrido-pubescenti, albo-farinosa. *Folia* obovata vel spatulata, 2-4 cm. longa, 1-1.5 cm. lata, petiolo brevi alato suffulta, margine bene dentata, supra scabrida, infra ad costam nervosque pilis brevibus crebre munita atque glandulis farini potentibus vel farina ipsa alba praedita. *Scapus* 12-18 cm. altus, ad apicem plus minusve farinosus, bracteis anguste lanceolatis vel paulo oblanceolatis 5-12 mm. longis sparsim farinosis, pedicellis brevibus vix 3-4 mm. excedentibus similiter farinosis, floribus 2-6 paulo congestis. *Calyx* 8-10 mm. longus, cylindricus vel anguste campanulatus, in lobos ovatos 2-3 mm. latos obtusos vel acutos nunc apice dentatos utrinque farinosos ad medium divisus. *Corollae* coeruleae tubus in floribus brevistylis calycem duplo superans, in floribus longistylis vix duplo, limbus ad 2 cm. diametro faucibus farina conspersus, lobi alte obcordati atque in sinu saepe apiculati. *Antherae* in floribus brevistylis 1 mm. longae, paulo sub os corollinum insertae, stylo tubum medium aequante. *Ovarium* globosum circ. 1.5 mm. diametro. *Capsula* 7-8 mm. longa, apice valvis quinque dehiscens.

TIBET. Valley above Trepri, alt. 13,500 ft., on grassy rock shelves. 'Under surface of leaves, scape and calyx sparingly farinose. Calyx green, occasionally tinged purple. Corolla-tube ruddy-purple, darker at apex. Segments pale lavender to deep violet-blue with white farinose eye. 26. 7. 38.' *Ludlow, Sherriff & Taylor* 5423—type. In the same valley and at the same altitude; in fruit. 25. 9. 38. *Ludlow, Sherriff & Taylor* 5423a.

Mr R. B. Cooke of Corbridge, Northumberland, germinated seeds of no. 5423a and brought the resulting plants to flowering in April 1940. Plants from the same source flowered in the Royal Botanic Garden, Edinburgh, in September 1940.

***Primula asarifolia*** Fletcher. Species affinis *P. obconicae* Hance sociisque, a quibus foliis forma valde diversis fere glabris inter alia differt; quoad habitum *P. chartaceam* Franch. in memoriam revocat sed flores ad sectionem Obconicam sine dubio tendunt.

*Planta* perennis rhizomate crassiusculo. *Folia* cum petiolis basi vaginantibus pubescentibus ad 10 cm. longa; lamina reniformis, subcoriacea, ad 4 cm. longa, ad 4.5 cm. lata, apice rotundata, basi alte cordata, margine undulata, nunc obscure lobulata, denticulis hydatioidibus subremotis notata, minute ciliata, glabra vel subglabra nisi utrinque ad margines; nervi laterales 2-3 paria, prope basim orientes. *Scapus* fere ad 25 cm. altus, basi pubescens, supra glabrescens, circ. 6-florus; in speciminibus nostris inflorescentiae vix maturae, pedicellis ad 10 mm. longis, bracteis lanceolatis ad 7 mm. longis, omnibus cum calycibus valde pubescentibus. *Calyx* campanulatus, 6 mm. longus, in lobos triangulares apiculatos ad trientem vel paulo ultra fissus. *Corollae* ex collectore

purpureae extra paulo puberulae tubus anguste cylindricus, ad 10 mm. longus; lobi obcordati, alte emarginati, 4 mm. longi, 3 mm. lati. In floribus longistylis *antherae* 2 mm. longae, supra basim tubi 3 mm. insertae; stylus 8 mm. longus; ovarium 1.5 mm. diametro.

YUNNAN. Chen-kang Hsien, alt. 7800 ft. 'Flowers purple. In mixed woods. March 1936,' Wang 72594—*type*.

This plant, so far as is known, seems to have been collected but once and the type specimen, Wang 72594, is in the Herbarium of the Arnold Arboretum. The leaves are strongly reminiscent of those of *P. chartacea* Franch. and *P. lacerata* W. W. Sm. of the Section Petiolares. The flowers and scape, however, bear no relationship to that section and place the plant undoubtedly in the Section Obconica.

**Primula cardioeides** W. W. Sm. et Fletcher (Section Carolinella) nom. nov. *P. cordata*, Merrill, non Balf. f.

This species was described in the Journal of the Arnold Arboretum (xx, p. 349; 1939). The name *P. cordata* is, however, preoccupied: Balfour used it in manuscript as a name for *P. cordifolia* Pax (Section Rotundifolia) seeing that *P. cordifolia* had already been used—*P. cordifolia* Rupr. (Section Vernales), and it was published in W. W. Smith and Forrest's sections of the Genus Primula (Notes Roy. Bot. Gard. Edinb. xvi, p. 42; 1928), where it is indicated that the name takes the place of the one used by Pax. The material on which Pax based a description of his *P. cordifolia* was very meagre and for a long time it was very doubtful what it really represented. It came from the same area in which *P. cardiophylla* is found and this latter plant as well as Pax's species is now regarded as a robust variety or state of *P. rotundifolia* Wall. Dr Merrill's plant belongs to an entirely different section found only in China. The new name chosen, like the original, is intended to call attention to the leaf shape.

**Primula chionogenes** Fletcher. In sectionem Petiolares atque in subsectionem Sonchifoliam ponenda; certe affinis *P. chionotae* W. W. Sm. a qua foliis grosse atque irregulariter dentatis, calycis lobis acutis bene denticulatis subflabellatim nervosis, floribus aureis divergit.

*Planta* modesta, glabra, efarinosa, squamis basalibus hiemalibus rubris oblongis apice acuminatis ad 3 cm. longis 1 cm. latis tempore florendi persistentibus bene circumdata. *Folia* cum floribus coaetanea, 6–8 cm. longa; lamina ipsa circ. 4 cm. longa, ovata vel late elliptica, apice rotundata, basi in petiolum membranaceo-alatum angustata, margine grosse dentata; in plantis fructiferis petiolus ad 10 cm. auctus atque lamina paulo cordata. *Scapus* obsoletus; flores 2–6, primo fere sessiles, tandem pedicellis 6–8 cm. longis fructu paululo elongatis suffulti. *Calyx* campanulatus, 1–1.3 cm. longus, ad medium vel paulo ultro in lobos ovatos apice acutos subflabellatim nervosos fissus; nervi in denticulos hydathodis terminatos excurrentes. *Flores* laete aurei, ad oculum fusco-aurei, annulati; corollae tubus primo calycem paulo superans tandem duplo longior, supra leviter amplatus; limbus 2.5–3 cm. diametro; lobi elliptici vel obovati, 10 mm. longi, 8 mm. lati, breviter emarginati, plerumque serratuli. *Stamina* in floribus brevistylis ad medium tubum inserta, antheris 2.5 mm. longis, filamentis 1 mm. longis. *Stylus* tantum 2 mm. longus; ovarium conicum, circ. 2 mm. altum, basi 2.5 mm. diametro.

SE. TIBET. Pachakshiri District: Lo La, on the south side, alt. 10,000 ft. Lat. 28° 46' N. Long. 94° 00' E. 'Corolla and lobes brightest golden yellow, richer at the throat. Tube swelled just above the calyx. Calyx dull green, lobes and chiefly margins of lobes dull red, dentate. Leaves dark green, the outer bud leaves red. Roots pale yellow. Although only 1½–2 in. high the flowers are nearly over. Seen only in one small closely compacted clump, 6 in. square, on steep open damp hillside, close to bamboo and rhododendron. 25. 4. 38.' Ludlow, *Sherriff & Taylor* 3648, 3754. Takpo Province: Chubumbu La, near Langong, alt. 13,000–14,000 ft. Lat. 28° 47' N. Long. 93° 44' E. 'Corolla golden yellow,

rich deep golden yellow in the eye. Tube paler yellow. No farina noticeable. Calyx and lobes green; lobes margined red in older plants. Pedicels green. Leaves dark green above, pale below, where veins are very prominent. In small plants before flowering the white bud leaves are tinged red, as are the leaves. Very common on South side only of Pass, in clumps 6 in. across, covering large areas of open hillside, preferring immediately beneath cliffs and down avalanche slopes. Plants 1- to 5-flowered. 7. 6. 38.' *Ludlow, Sherriff & Taylor* 3983—*type*. Also 17. 10. 38, *Ludlow, Sherriff & Taylor* 6609. Tsari Sama, Langong, alt. 14,000 ft. Lat. 28° 45' N. Long. 94° 00' E. 'In tightly rooted clumps, on open wet meadows. Flowers nearly over. 16. 6. 38.' *Ludlow, Sherriff & Taylor* 5573. 'On open grassy steep hillside, south face. 16. 6. 38.' *Ludlow, Sherriff & Taylor* 5579. 'On open wet meadows but rather sandy soil. 12. 10. 38.' *Ludlow, Sherriff & Taylor* 6601.

Plants of numbers 3648 and 6609 were sent to the Royal Botanic Garden, Edinburgh, by air mail from India in 1938. These plants flowered in March 1940.

***Primula comata* Fletcher.** Species arcte affinis *P. taliensi* G. Forrest, a qua foliis oblongis vel obovatis in sicco chartaceis, pedunculis calyceibusque pedicellisque valde villosis, corollae lobis integris inter alia divergit.

*Planta* nana, efarinosa, pilis septatis longis brunneis omnino (corolla excepta) bene induta. *Squamae* basales deciduae, ellipticae vel oblongo-ellipticae, circ. 1.5 cm. longae, 0.5 cm. latae. *Folia* chartacea, oblonga vel obovata, ad 5 cm. longa, ad 2 cm. lata, apice rotundata, in petiolum late alatum cito angustata, margine irregulariter crenato-serrata, nervis utrinque inconspicuis. *Scapus* folia aequans vel paulo superans, umbellam vulgo 6-8-floram gerens; bractae ovato-lanceolatae vel lanceolatae, circ. 8 mm. longae, basi circ. 2.5 mm. latae; pedicelli 1.5 cm. longi, erecti, apice paulo incrassati. *Calyx* tubuloso-campanulatus, 8 mm. longus, in lobos ovatos acutos fere ad medium fissus. *Corollae* (ex collectore) coeruleae tubus 1-1.2 cm. longus, intus ad fauces bene villosulus, limbus 1.5-2 cm. diametro, lobi late obovati, integri, intus ad basim villosuli. *Stamina* in floribus brevistylis paulo ultra calycem inserta, in floribus longistylis tubum corollinum medium aequantia, antheris 2 mm. longis, filamentis 0.75 mm. *Stylus* in floribus longistylis ad os attingens, 10-11 mm. longus, in floribus brevistylis tantum 4 mm. longus. *Ovarium* globosum, 1.5 mm. diametro.

YUNNAN. Chen-kang Hsien, alt. 2800 m. 'Woods, rock side.' *Wang* 72630—*type*. Chen-kang Hsien, alt. 3200 m. 'Border of woods. Local, frequent.' *Wang* 72443.

***P. Dickieana* Watt, var. *Gouldii* Fletcher, var. nova.** Habitu robustiore, foliis multo majoribus, pedicellis longioribus, corollae lobis suborbicularibus minoribus a typo differt.

*Planta* glabra efarinosa. *Folia* chartacea, 8-12 cm. longa, 1.5-2 cm. lata, lanceolata, apice acuta vel subacuminata, basi in petiolum alatum angustata, margine integra vel obscure denticulata, minute punctulata, viridia vel pallide brunnea, costa conspicua, nervatione tenui obscura. *Scapus* 15-23 cm. altus, umbellam florum 2-4 nutantium gerens, bracteis linearibus circa 1 cm. longis vel triangularibus circa 4 mm. longis apice longe attenuatis, pedicellis 1-1.5 cm. longis. *Calyx* 8-10 mm. longus, tubulosus, coriaceus, 15-nervatus, lobis circa 3 mm. longis basi 2 mm. latis apice attenuatis. *Corollae* tubus in flore brevistylis circa 1.5 cm. longus cylindricus supra stigma paulo ampliatus intus minute puberulus, limbus planus vel subplanus basi minute puberulus, lobis subrotundatis 5-7 mm. diametro apice emarginatis. *Stamina* in flore brevistylis 2-75 mm. longa, ad apicem tubi corollini inserta, antheris 2 mm. longis. *Ovarium* globosum, circa 2 mm. diametro; stylus 2 mm. longus; stigma discoideum.

BHUTAN. Minting, Oroling, Ra La, circa 12,000 ft., June 20-26, 1938, *Gould* 559—*type*, 580 (in Herb. Kew). Tripte La, circa 14,000 ft., June 11, 1938, *Gould* 440 (in Herb. Kew).

This variety, which was collected by Gould in Bhutan in 1938, has a more robust habit than the type, with longer leaves, longer pedicels, and smaller suborbicular corolla lobes.

**Primula inopinata** Fletcher. Species aliquatenus anomala, in gregem Muscarioides ponenda, floribus in racemum laxum dispositis nec dense spicatis distinguenda.

*Planta* ad 18 cm. alta, efarinosa, glanduloso-hirsuta, aromatica. *Folia* dense rosulata, oblonga vel oblongo-obovata, ad 6 cm. longa, ad 2 cm. lata, apice obtusa, in petiolum late alatum angustata, margine lobulata atque irregulariter dentata, utrinque pilis simplicibus atque pilis septatis glanduloso-capitatis praedita, nervis 4-6-paribus supra immersis infra prominentibus angulo fere recto abeuntibus. *Scapus* ad 18 cm. altus, validus, glanduloso-pubescent, racemum laxum circ. 10-florum hyacinthodorum gerens; bracteae oblongae vel oblanceolatae, 5 mm. longae, nunc paulo dentatae; pedicelli 2 mm. longi. Flores dimorphici. *Calyx* tubuloso-campanulatus, 5 mm. longus, rubro-striatus, in lobos paulo obovatos 2 mm. latos apice rotundatos atque paulo incurvatos ultra medium fissus. *Corollae* limbus patens, 1.5 cm. diametro, saturate coeruleo-violaceus nisi ad sinus albidus; tubus anguste cylindricus, 10-12 mm. longus, paulo curvatus, exannulatus, pallido-coeruleus atque violaceo-striatus; lobi obcordati, 7 mm. longi, 5 mm. lati, ad trientem emarginati, bene mucronulati, nunc paulo inaequales. *Stamina*, antheris 1 mm. longis, in floribus longistylis a basi tubi corollini 4 mm. inserta. *Stylus* tubum fere aequans. *Ovarium* globosum, 1.5 mm. diametro.

YUNNAN. Chung-tien (Chiren), alt. 9300 ft. 'Under forest; rocky places. Oct. 24, 1937.' *Yü* 13861—*type* cult.

The herbarium specimen of *Yü* no. 13861 is in fruit, but is undoubtedly *P. aromatica* W. W. Sm. & Forrest, an interesting species of the Section Malvacea which Forrest found on the Ta-li Range and which in the dried condition has the fragility associated with dried plants of *Impatiens*. Seeds under the number *Yü* 13861 were sent to the Royal Botanic Garden, Edinburgh. These germinated in 1939 and plants were brought to the flowering stage in August 1940. These plants bear no relationship to *P. aromatica*, but represent the new species described above. Its foliage shows a strong resemblance to the foliage of the species in the Section Muscarioides and to *P. pinnatifida* Franch. in particular, but in the characters of the inflorescence *P. inopinata* is quite distinct from every other species in the section. The flowers are arranged in a loose raceme and not in a close spike or capitulum and in the flower-bud the posterior and postero-lateral calycine lobes do not cover the rest of the flower, and thus there is no overlapping of segments to give the surface of the young inflorescence an imbricate appearance, as of a tiled roof. This species stands in the same relationship to the Section Muscarioides as do *P. spicata* Franch. and *P. siamensis* Craib to the Section Soldanelloideae.

**Primula Rhodochroa** W. W. Sm. *var. melotera* W. W. Sm. et Fletcher, *var. nov.* Haec planta primo intuitu a specie ipsa aliquatenus diversa esse videtur sed speciminibus intermediis conjungitur; vix ut species propria judicari potest. Foliis longioribus angustioribus longius petiolatis grossius dentatis, scapo bene evoluto, floribus multo minoribus differt.

*Planta* pusilla, caespitosa, ad 4 cm. alta. *Folia* spathulata vel oblanceolata, ad 3 cm. longa, ad 5 mm. lata, apice acuta, basi in petiolum vix discretum anguste alatum sensim angustata, margine pro magnitudine grosse dentata, dentibus subreflexis, glabra, supra farina leviter conspersa, infra dense albo-farinosa. *Scapus* gracilis, ad 4 cm. altus, farinosus, 1-2-florus; bracteae ad 5 mm. longae, lineares, farinosi. *Pedicelli* graciles, farinosi, ad 10 mm. longi. *Calyx* poculiformis vel urceolato-campanulatus, circ. 4 mm. longus, extra farinosus, paulo sub medium fissus, bene costatus, lobis anguste lanceolatis vel oblongo-lanceolatis apice acutis vel subobtusis. *Corolla* monomorphica, coerulea, extra farina conspersa; tubus calycem aequans; limbus 5-8 mm. diametro; lobi obcordati emarginati. *Stamina* paulo infra os corollinum inserta, antheris 0.5 mm. longis. *Stylus* ad os pertinens; ovarium globosum, 1.5 mm. diametro; capsula calycem aequans, valvis obtusis vel acutis dehiscens.

TIBET. Pero La, alt. 13,000 ft. 'In soil pockets amongst moraine boulders. Leaves



(both surfaces), pedicels and calyx copiously white-farinose. Calyx green. Corolla pale to deep violet-blue, darker shade towards throat which is white-farinose. Corolla-tube farinose outside, greenish-yellow outside and within. Lobes with sprinkling of farina on reverse. Anthers light brown. 12. 7. 38.' *Ludlow, Sherriff & Taylor* 5218—*type*.

This variety appears at first sight to represent a distinct species in close alliance with *P. rhodochroa*. The typical plant of the latter has much larger flowers, shorter and broader leaves and practically no scape. Nevertheless, the flower, as in some other *Primulas*, varies much in size and the degree of evolution of the scape may well depend on the environmental conditions.

***Primula Tsongpenii* Fletcher.** Ab speciebus omnibus sectionis *Dryadifoliarum* faucibus corollae pilis albis densissime faretis facile distinguitur.

*Herba* parvula, glabra, paene efarinosa. *Rhizoma* tenue, ad 5 cm. persistens, foliis vetustis apice vestitum, ramos emittens. *Folia* ad 10 mm. longa, 4–5 mm. lata: lamina ipsa rotundata, 10–12-dentata, coriacea, utrinque glabra efarinosa: petiolus arcte distinctus, 5 mm. longus, 2 mm. latus, membranaceo-alatus. *Scapus* ad 5 mm. longus, inter folia immersus, uniflorus. *Bracteae* 2–3, 3–5 mm. longae, ciliolatae, minute farinosae, scutiformes. *Calyx* campanulatus, 5 mm. longus, luteo-farinosus, ad medium 5-lobatus; lobi ovati vel elliptici, 2.5–3 mm. lati, apice rotundati, farinosi, ciliolati. *Corolla* violacea; tubus 9–10 mm. longus, cylindricus, extra glaber, intus ad fauces pilis longis albis dense pulvinatim aggregatis clausus: limbus expansus circa 15 mm. latus: lobi obcordati, bilobati: lobuli emarginati. *Stamina* in flore brevistylis supra basin tubi corollini 4–4.5 mm. adfixa. *Ovarium* globosum, circ. 2 mm. diametro: *stylus brevis* 1 mm. longus, *stylus longus* calyce paulo longior. *Capsulae* seminaeque non visae.

SE. TIBET. Tsanang La, near Paka, alt. 14,000–14,500 ft. 'Corolla slightly purplish bright pink. Eye lemon yellow, with a tuft of white hairs at the throat. Tube wine red. Calyx green, with a tinge of brown-red and a good deal of farina. Some farina also on scape and back of leaves. Forming mats on the bare open rocky hillside, growing among *P. Valentiniana* and close to *P. Jonarduni*. 18. 7. 38.' *Ludlow, Sherriff & Taylor* 5865, *type*. Kucha La, near Paka, alt. 14,000–15,000 ft. 'Common in this area, always on bare open hillside, forming close growing mats of flowers. 25. 7. 38.' *Ludlow, Sherriff & Taylor* 5931. Lo La, near Molo, alt. 14,000 ft. 'Ripe seeds taken. Coming into flower again now. Forming mats in mossy ground on rocks. 7. 10. 38.' *Ludlow, Sherriff & Taylor* 6554.

The plant, named after Tsongpön, a native collector, has never been in cultivation and is known only from the collections of Ludlow, Sherriff and Taylor which are in the British Museum. It is easily distinguished from the other members of the section *Dryadifolia* by the possession of a pompon of hairs in the throat of the corolla. Other species in the section have a few scattered hairs in the corolla-tube and at the base of the corolla-limb, but in no other species are the hairs so numerous and concentrated in the corolla-throat.

***Primula Youngeriana* W. W. Sm.** Species valde affinis *P. obtusifoliae* Royle, a qua calyce elongato corollae tubum aequante vel nunc superante ad imum in lobos plus minusve patentes recedit.

*Planta* farinosa ad 45 cm. alta. *Folia* in sicco tenuiter chartacea, elliptica vel oblongo-elliptica vel oblanceolata vel nunc obovata, ad 25 cm. longa, ad 6 cm. lata, apice rotundata vel obtusa, basi in petiolum alatum laminae subaequalem cuneatim angustata, margine plus minusve regulariter crenato-denticulata, glabra, infra dense albo-farinosa vel tandem viridescens. *Scapus* ad 45 cm. altus, infra glandulis farini-potentibus conspersus, ad apicem dense albo-farinosus: flores nunc solitarii, plerumque 3–6-umbellati, nonnunquam in umbellas duas superpositas ordinati: bracteae lineares, ad 4 cm. longae, ad 2 mm. latae, farinosae: pedicelli 1–5 cm. longi, tandem in statu fructifero ad 9 cm. elongati,

farinosi. *Calyx* 1-1.5 cm. longus, in fructu ad 2.5 cm. auctus, in lobos lanceolatos acutos vel obtusos extra leviter farinosos virides vel nigrescentes intus farina dense indutos fere ad imum fissus. *Corolla* atro-violacea vel lilacina, oculo magno albo, annulata; tubus calycem plus minusve aequans: limbus 2-3 cm. diametro: lobi oblongo-elliptici vel obovati, 13 mm. longi, 8 mm. lati, integri. *Stamina* ad medium tubum inserta vel in floribus brevistylis ad annulum pertinentia, filamentis 0.5 mm. longis, antheris 1 mm. *Stylus* vix medium tubum aequans vel in floribus longistylis ad annulum porrectus. *Ovarium* globosum, 2 mm. diametro: capsula ut videtur longitudine variabilis, nunc calyce brevior, nunc aequans vel paulo longior, valvis 5 retroversis dehiscens.

SE. TIBET. Mira La, Nyang Chu, alt. 15,000 ft. Lat. 29° 30' N. Long. 94° 15' E. 'Habitat similar to that of *Primula rotundifolia*, close to which it was growing, under huge boulders in dry moss. Under surface of leaves, scape, bracts, calyx lobes (especially within) white farinose. Corolla tube and segments usually deep blue violet, sometimes lilac, with large white eye. Segments farinose on reverse. Leaves flaccid. 14. 8. 38.' Ludlow, Sherriff & Taylor 6061—type.

The nearest ally is undoubtedly *P. obtusifolia* Royle, a rare species confined to the NW. Himalaya. The distinction is in the calyx which is unusually large in *P. Youngeriana* and is cut to the base into markedly patent lobes. The habitat of the new species is in SE. Tibet and there is no record in the broad intervening territory (Bhutan, Sikkim, Nepal) of either species or of any intermediate. The specific name is in honour of Mr Harry Younger of Benmore, devoted to horticulture and to forestry.

New species and varieties of *Eriachne* R.Br.—family Gramineae. By W. HARTLEY.  
(Communicated by A. D. Cotton, O.B.E., F.L.S.)

[Read 6 March 1941]

A STUDY has been made of the material of *Eriachne* R.Br. available at Kew, preparatory to a revision of this genus of Gramineae, and the following species and varieties are described as new. Except where otherwise indicated, the specimens listed are in the Kew Herbarium: those from other herbaria are indicated as follows: (Mus. Brit.), in the British Museum Herbarium; (Herb. Brisb.) in the Brisbane Herbarium; (Herb. Domin.) in the Domin Herbarium at Prague.

*Eriachne stipacea* F. Muell. var. *hirsuta* Hartley, var. nov.; a typo culmis ramosis, culmis et vaginis et laminis dense hirsutis, glumis sparse pilosis, glumis et aristis paullo brevioribus differt.

Northern Territory (Australia). Near Darwin, on wet land, common, *Allen* 141.

*Eriachne sulcata* Hartley, sp. nov.; affinis *E. glaucae* R.Br., a qua nodis barbatis, glumis pilis crassis patulis praeditis et inter nervos haud hispidulis, glumis (6–10 mm.) et lemmatibus (5–7 mm.) longioribus differt.

*Gramen* perenne (?), caespitosum. *Culmi* erecti vel nonnihil geniculati, circiter 50–70 cm. alti, 3–4-nodes, simplices vel leviter ramosi, teretes, glabri vel infra paniculam nonnunquam sparse pilosi; nodi barbati. *Foliorum vaginæ* teretes, internodiis plerumque breviores, apice et basin versus sparse pilosae, ceterum glabrae; ligulae breviter ciliatae; laminae lineares, planae vel plus minusve involutae, 10–25 cm. longae et 2–5 mm. latae, supra hispidulae, subtus laeves vel sparse hispidae, marginibus crassis scabridis. *Panicula* ovata vel oblonga, contractiuscula vel nonnihil laxa, 4–8 cm. longa et 2–4 cm. lata; rhachis et rami minute scaberuli. *Spiculae* breviter pedicellatae, stramineae vel purpureae. *Glumae* aequales, ovatae, acuminatae, haud carinatae, 6–10 mm. longae, chartaceae, conspicue 9-nerves, dorso pilis crassis patulis praeditae, haud hispidulae. *Lemmata* lanceolata, 5–8 mm. longa, infra medium tenuiter chartacea et villosa, supra medium membranacea, conspicue 7-nervia, prope margines anguste sulcata, in aristam tenuem curvatam scaberulam 1–2 cm. longam producta. *Paleae* lanceolatae, apice minute bidentatae, membranaceae, lemmatibus aequilongae, infra medium pilosae. *Antherae* circiter 2 mm. longae.

Western Australia. Near a native well, 9 miles from Goody Goody, *Fitzgerald* 315 (type); West Napier Ranges, *Basedow* 40.

Northern Territory. Victoria River, *Elsey*; Van Diemen's Gulf, in low humid situations, *Cunningham* (Mus. Brit.).

The specimens here separated as a new species have usually been referred to *Eriachne squarrosa* R.Br. (e.g. by Bentham in the *Flora Australiensis*), but can be distinguished readily from that species by the smooth culms and sheaths, and particularly by the acute lemmas, which are villous only on the lower half and with two prominent lateral grooves above. *E. sulcata* appears to be confined to northern Western Australia and adjacent parts of the Northern Territory, while *E. squarrosa* extends from north-eastern Queensland to New Guinea and the Moluccas.

*Eriachne glauca* R.Br. shows a much closer relationship to *E. sulcata*, but in the former species the glumes are villous with slender weak hairs and conspicuously hispidulous between the nerves, and, except in the variety described below, the nodes are always glabrous.

*Eriachne glauca* R.Br. var. *barbinodis* Hartley, var. nov.; a typo *nodis barbatis*, panicula laxiore, glumis et lemmatibus paullo longioribus differt.

Queensland. Swamps between Townsville and Rolleston, *White* 8913 (Herb. Brisb.).

*Eriachne filiformis* Hartley, sp. nov.; affinis *E. agrostideae* F. Muell., a qua *nodis* villosis, vagina suprema internodio multo brevior, panicula contractiuscula purpurea, pedicellis brevioribus sparse pilosis, lemmatibus ad margines dense hirsutis, aristis brevioribus 2.5–6 mm. longis differt.

*Gramen* annuum, caespitosum, humile, innovationibus numerosis. *Culmi* erecti, 3–15 cm. alti, gracillimi, 2–4-nodes, internodio supremo longissimo, ramosi, purpurascens, glabri vel breviter pilosiusculi, nodi plus minusve pilosi. *Foliorum vaginae* teretes, striatae, inferiores internodiis aequilongae, supremae internodiis multo breviores, hispidae et apice pilosae; ligulae breviter ciliatae; laminae filiformes, involutae, eae foliorum inferiorum usque ad 5 cm. longae, superiorum gradatim breviores, pilis patulis e tuberculis ortis praeditae. *Panicula* contractiuscula, 1–2 cm. longa; rami capillares, purpurei, ut rhachis plerumque sparse pilosi; pedicelli capillares, apicem versus nonnihil crassiores. *Spiculae* biflorae, purpureae, 2.5–5 mm. longae (aristis exclusis). *Glumae* subaequales, anguste ovatae vel ellipticae, acuminatae, 3–5 mm. longae, conspicue 9–11-nerves, membranaceae, prope margines purpureae, dorso hispidae. *Lemmata* elliptica, 2–3 mm. longa, 7-nervia, nervis lateralibus obscurissimis, tenuiter cartilaginea, infra medium margines versus dense hirsuta, supra medium glabra, arista gracillima recta 3–4 (raro 6) mm. longa praedita. *Paleae* ellipticae vel obovatae, hyalinae, lemmatibus aequilongae, dorso minute appresso-pubescentes. *Caryopsis* anguste obovata, 1.5–3 mm. longa.

Northern Territory. Arnhem Land, *Basedow* 53, 81 (type).

Queensland. Endeavour River, *Banks & Solander* (Mus. Brit.); Palmer River, *Lea* (Mus. Brit.).

The first specimen cited (*Basedow* 53) has longer glumes and lemmas than the type, but all the specimens are very uniform in general habit. It is interesting to note that the specimen collected by Banks and Solander at Endeavour River, and now at the British Museum, was apparently overlooked by Robert Brown in the preparation of his 'Prodromus'.

*Eriachne humilis* Hartley, sp. nov., affinis *E. filiformi* Hartley et *E. ciliatae* R.Br.; ab illa panicula paucispiculata, ramis paniculae et pedicellis longioribus patulis, glumis glabris nonnihil obtusis haud acuminatis, lemmatibus glumis aequilongis, aristis brevioribus praeditis, ab hac habitu gracillimo, nodis paucioribus, culmis laevibus, internodio supremo longissimo, laminis angustissimis involutis, panicula minore, nervis glumarum conspicuis, lemmatibus plerumque longioribus differt.

*Gramen* annuum, caespitosum, humile. *Culmi* erecti vel nonnihil geniculati, plerumque 2–3-nodes, e nodis inferioribus ramosi, gracillimi, usque 20 cm. alti, laeves et glabri; nodi glabri vel sparse pubescentes. *Foliorum vaginae* striatae, nonnihil laxae, inferiores internodiis fere aequilongae, supremae internodiis longissimis multo breviores, hispidae; ligulae breviter ciliatae; laminae erectae vel patulae, angustissimae, arcte involutae, haud rigidae, usque 3 cm. longae, hispidae. *Panicula* erecta, laxa, 1–3 cm. longa, spiculis paucis (plerumque 3–5) praedita; rami et pedicelli patuli, rigidiusculi, 4–15 mm. longi, graciles sed apicem versus crassiores, glabri. *Spiculae* biflorae, stramineae, circiter 4 mm. longae (aristis exclusis). *Glumae* ellipticae vel anguste obovatae, obtusiusculae, tenuiter chartaceae, conspicue 9–11-nerves, circiter 4 mm. longae et 2 mm. latae, glabrae. *Lemmata* elliptica vel lanceolata, circiter 3.5 mm. longa, tenuiter chartacea, conspicue 7-nervia, straminea, apicem versus excepta dense hirsuta, apice glabra et in aristam rectam 2–3 mm. longam producta. *Paleae* ellipticae, hyalinae, lemmatibus aequilongae.

Queensland. Thursday Island, on rocks, *Bailey* in 1897 (type in Herb. Brisb.).

***Eriachne Basedowii* Hartley, sp. nov.**; perennis; culmi erecti, glabri sed infra paniculam scaberuli; nodi barbati; vaginae basi dense lanatae; laminae angustissime lineares, involutae, pungentes; panicula coarctata, subspiciformis, 2.5–3.5 cm. longa; glumae oblongo-lanceolatae, circiter 7 mm. longae, dense villosae; lemmata circiter 6 mm. longa, infra medium villosa, aristulata.

*Gramen* perenne, caespitosum, basi dense lanatum. *Culmi* erecti, simplices, teretes, infra paniculam scaberuli, ceterum glabri; nodi pilosi. *Foliorum vaginae* teretes, eae culmorum glabrae vel basin versus pilosae, internodiis plerumque breviores, eae innovationum basi dense lanatae; ligulae breviter ciliatae; laminae anguste lineares, erectae, rigidae, arcte involutae, pungentes, plerumque 5–12 cm. longae, glabrae vel sparse hispidae. *Panicula* contractissima, subspicata, 2.5–3.5 cm. longa et 7–10 mm. lata; rami brevissimi. *Spiculae* biflorae, subsessiles, brunneolae. *Glumae* aequales, lanceolato-oblongae, nonnihil obtusae, circiter 7 mm. longae, 9-nerves, dorso dense villosae. *Lemmata* tenuiter chartacea, lanceolata, circiter 6 mm. longa, conspicue 7-nervia, infra medium villosa, supra medium scaberula et in aristam rectam circiter 1.5 mm. longam producta, haud sulcata. *Paleae* lanceolatae, acuminatae, lemmatibus aequilongae, apice excepto appresso-pubescentes.

Northern Territory. Arnhem Land, *Basedow* 116 (type).

This species is readily distinguished from all others by its densely woolly base, stiff narrow involute blades, and compact densely villous panicles.

***Eriachne aristidea* F. Muell. var. *minor* Hartley, var. nov.**; typo minor; culmi usque 25 cm. alti; glumae 4.5–5 mm. longae; lemmata circiter 4.5 mm. longa, arista brevi (circiter 1 mm. longa) praedita.

Western Australia. Munberry Station, Lyons River, *Gardner* 3031 (type).

*E. aristidea* is common on sandhills in most of the arid parts of Australia. While it shows considerable variation in pubescence and length of awns, the species as a whole is well-marked, and, with the exception of the one described above, it does not seem possible to separate distinct varieties. The specimen distinguished as var. *elegans* Domin (Journ. Linn. Soc. Lond., Bot. xli, p. 279; 1912) appears to be only a rather immature form and not taxonomically distinct from the species.

***Eriachne Gardneri* Hartley, sp. nov.**; affinis *E. aristidea* F. Muell., a qua ramis paniculae haud divaricatis et sine pulvinis conspicuis, glumis tantum margines versus sparse hispidis, lemmatibus mucronatis haud aristatis pilis brevioribus praeditis differt.

*Gramen* annuum, caespitosum, glaucum. *Culmi* validiusculi, erecti vel geniculati, leviter ramosi, teretes, 30–40 cm. alti, 2–4-nodes, laeves et glabri; nodi pubescentes. *Foliorum vaginae* teretes, striatae, nonnihil laxae, internodiis breviores, apice piloso excepto laeves et glabrae; ligulae dense ciliatae, circiter 1 mm. longae; laminae lineares, planae, nonnihil flaccidae, plerumque 8–18 cm. longae et 3–5 mm. latae, supra minute hispidulae, subtus glabrae et laeves. *Panicula* erecta, anguste oblonga, 5–7 cm. longa et 1.5–2 cm. lata; rami plus minusve appressi, nonnihil crassi, sparse hispidi, basi pubescentes; pedicelli breves, crassi, glabri. *Spiculae* biflorae, 8–9 mm. longae, glaucescentes. *Glumae* subaequales, membranaceae, anguste ovatae vel lanceolatae, acutae vel obtusiusculae, 8–9 mm. longae et 3–4 mm. latae, conspicue 11–15-nerves, laeves et nitentes sed margines versus pilis paucis robustis e tuberculis ortis praeditae. *Lemmata* tenuiter cartilaginea, anguste ovata, circiter 7.5 mm. longa et 3–3.5 mm. lata, infra medium pilis rectis lemmatibus brevioribus dense villosa, supra medium glabra vel minute puberula, 7-nervia, sulcata, mucronulata. *Paleae* chartaceae, lanceolatae, lemmatibus aequilongae, infra medium villosae, apice bimucronulatae. *Antherae* 4.5–5 mm. longae.

Western Australia. Ashburton River, Minderoo, on sand dunes, *Gardner* 3053 (type).

***Eriachne pallescens* R.Br. var. *Muelleri* (Domin) Hartley, stat. nov. *E. Muelleri* Domin in Fedde, Repert. Spec. Nov. x, p. 118 (1911).**

Domin, in describing *E. Muelleri*, separates it from *E. pallescens* R.Br. by the biaristate palea, stating that in the latter species the palea is entire. However, many specimens of *E. pallescens* have two distinct short awns, up to 1.5 mm. long on the palea, and var. *Muelleri* appears to be distinguished from the typical forms only by the greater length of the palea-awns, these being around 3 mm. long.

***Eriachne anomala* Hartley, sp. nov.; affinis *E. pallescenti* R.Br., a qua habitu gracili, laminis flaccidioribus haud scabridis, pedicellis longioribus divaricatis, spiculis 1- (raro 2-)floris, glumis (2.5 mm.) et lemmatibus (3 mm.) brevioribus, aristis lemmatibus plerumque duplo longioribus differt.**

*Gramen* perenne, caespitosum, gracile. *Culmi* gracillimi, teretes, leviter ramosi, erecti vel leviter geniculati, plerumque 4-5-nodes, 40-60 cm. alti (raro breviores), laeves et glabri; nodi laeves. *Foliorum vaginæ* teretes, marginibus hyalinis, internodiis multo breviores, laeves et glabrae vel apice sparse pilosae; ligulae brevissime ciliatae; laminae anguste lineares, erectae, planae vel involutae, flaccidae vel nonnihil rigidae, haud pungentes, usque 15 cm. longae et 1.5 mm. latae, supra minute puberulae, subtus laeves et glabrae. *Panicula* erecta, primo contracta, mox laxissima, ovata, 8-12 cm. longa et 4-8 cm. lata vel nonnunquam minor; rhachis gracilis, minute asperula et nonnunquam sparsissime pilosa; rami distantes, gracillimi, rigidi, demum divaricati, minute asperuli et basi pubescentes; pedicelli capillares, longi, patentes. *Spiculae* 1- (raro 2-) florae, purpureae vel stramineae. *Glumae* aequales vel prima major, anguste ovatae, obtusiusculae, membranaceae, 9-11-nerves, 2.5-3 mm. (raro 2 mm.) longae et circiter 1.5 mm. latae, laeves et glabrae. *Lemmata* anguste ovata vel ovata, acuminata, nonnihil cartilaginea, obscure 7-nervia, teretia, fere usque ad apicem appresso-pubescentia, 3-3.5 mm. longa, in aristam gracilem rectam 4.5-5.5 mm. longam (raro breviorem) producta. *Paleae* ovatae, acutae, chartaceae, lemmatibus aequilongae, dorso appresso-pubescentes. *Caryopsis* anguste elliptica, circiter 2 mm. longa, rubra.

Queensland. Bribie Island, *White* in 1915 (type: Herb. Kew and Herb. Brisb.) and in 1916 (Herb. Brisb.); loose sand among bracken in mixed open forest, *Blake* 4826; Fraser Island, Sandy Cape, *Lovell* in 1892 (Herb. Brisb.); in Eucalyptus forest on sandy soil, *Hubbard* 4568.

This species, known only from two islands off the coast of southern Queensland, is closely related to the very widespread *E. pallescens* R.Br., but differs from it, as from all other species of the genus, in the normally one-flowered spikelets. The possession of two equal florets in the spikelets is characteristic of *Eriachne*, but in a few species, notably the small annuals, *E. capillaris* R.Br. and *E. Dominii* Hartley, the second floret may be noticeably smaller than the first, while one-flowered spikelets are very occasionally found in *E. pallescens*.

***Eriachne Bentharii* Hartley, stat. nov. *E. ovata* Nees var. *pallida* Benth. Fl. Austral. vii, p. 631 (1878). Affinis *E. ovatae* Nees, a qua habitu robusto, culmis altis 3-6-nodibus semper glabris, laminis longioribus plus minusve planis haud arcte involutis, panicula longiore anguste oblonga vel lineari, glumis brevioribus (4.5-6 mm. longis) differt.**

*Gramen* perenne, caespitosum, robustum, glaucum. *Culmi* erecti, validiusculi, leviter ramosi, plerumque 3-6-nodes, 40-60 cm. alti, laeves et glabri; nodi glabri vel superiores nonnunquam pubescentes. *Foliorum vaginæ* teretes, internodiis aequilongae vel breviores, glabrae; ligulae breviter ciliatae; laminae rigidae, lineares, erectae, planae vel nonnihil involutae, usque 25 cm. longae et 4 mm. latae, supra scaberulae et basi plerumque hirsutae, subtus laeves et glabrae. *Panicula* anguste oblonga vel linearis, nonnihil contracta, 6-10 cm. longa; rhachis erecta, glabra; rami graciles, appressi, glabri vel scaberuli vel raro sparse pilosi; pedicelli brevissimi. *Spiculae* biflorae, stramineae vel

purpurascentes. *Glumae* aequales, anguste ovatae, obtusiusculae, membranaceae, 11–13-nerves, 4.5–6 mm. longae, glabrae et laeves, marginibus hyalinis. *Lemmata* lanceolata, acuta, chartacea, 7-nervia, 6–7.5 mm. longa, infra medium dense villosa, supra medium scaberula, sulcata, recurvata, mucronulata. *Paleae* anguste lanceolatae, lemmatibus aequilongae, infra medium villosae, supra medium scaberulae, lemmatibus divergentes.

Western Australia. Onslow, Ashburton River, *Gardner* 3060; clay pans near Onslow, *Gardner* 3068; Carnarvon, Shark's Bay, ex *Herb. A. Morrison*; Wongarwal Station, near Wiluna, *Gardner* in 1931.

Central Australia. Coglein River, *Basedow* 6; Charlotte Waters, *Giles* (type).

South Australia. Vicinity of Lake Eyre, *Andrews*; Cordello Downs, *Cleland* H255; Ross's Waterhole, Macumba River, *Cleland* H254, H256.

*Eriachne flaccida* Hartley, sp. nov.; affinis *E. Benthamii* Hartley et *E. ovatae* Nees; ab illa habitu gracili, culmis brevioribus plerumque 2-nodibus, laminis angustissimis flaccidis, panicula brevior, glumis et lemmatibus brevioribus; ab hac culmis vaginis et laminis semper glabris, laminis flaccidioribus, panicula laxiore, glumis brevioribus, lemmatibus brevioribus pilis gracilioribus praeditis differt.

*Gramen* perenne, caespitosum. *Culmi* graciles, simplices, erecti, 1–3 (plerumque 2-) nodes, 15–30 cm. alti, laeves et glabri vel infra paniculam sparse pilosi; nodi glabri, vel raro puberuli. *Foliorum vaginae* teretes, internodiis breviores, glabrae, inferiores basi breviter lanatae; ligulae brevissime ciliatae; laminae anguste lineares, flaccidae, involutae, plerumque 8–20 cm. longae et 1 mm. latae, supra scaberulae, subtus laeves et glabrae. *Panicula* erecta, contracta vel laxiuscula, plerumque 4–6 cm. longa (raro brevior) et 1–2 cm. lata; rami graciles, appressi vel nonnihil patentis, pilosi; pedicelli gracillimi. *Spiculae* biflorae, stramineae vel purpureae. *Glumae* anguste ovatae, obtusiusculae vel acutae, membranaceae, 9–11-nerves, 3.5–4.5 mm. longae, laeves et glabrae, marginibus hyalinis. *Lemmata* lanceolata, acuta, tenuiter chartacea, conspicue 7-nervia, 5–6.5 mm. longa, infra medium pilis gracilibus dense villosa, supra medium glabra recurvata. *Paleae* anguste lanceolatae, acutae, tenuiter chartaceae vel hyalinae, lemmatibus aequilongae, infra medium pilosae, supra medium glabrae, lemmatibus divergentes.

Western Australia. De Grey River, *Anderson* in 1899; Murchison District, *Buchanan* in 1925; north of Meekatharra, *Gardner* in 1931; Yundamindra Run, 120 miles NW. of Kalgoorlie, *Pearse* in 1931; Pindinni, 79 miles ENE. of Menzies, *Helms* in 1899 (type); east of Laverton, *Clarke* 106; without precise locality, *Gardner* 2393.

In contrast to true *Eriachne ovata* Nees, which occurs through the sclerophyllous forest and mallee country of Western Australia from Perth to Kalgoorlie, *E. Benthamii* and *E. flaccida* are characteristic of the more northerly belt of mulga country. In the eastern part of their range they are very distinct, but a few collections from the Ashburton and Gascoyne Rivers show some intermediate features, the panicles varying greatly in size and shape. It seems probable that considerable hybridization occurs in this area, a condition which would appear to be greatly facilitated by the character of the florets, which, in this group of species, have widely divergent lemmas and paleas.

*Eriachne tenuiculmis* Hartley, nom. nov. *E. pallida* F. Muell. ex Benth. Fl. Austral. VII, p. 631 (1878), non Nees (Fl. Afr. Austr. p. 274; 1841).

*Eriachne Helmsii* Domin, stat. nov. *E. mucronata* R.Br. var. *villiculmis* Domin in Bibl. Bot. XX, Heft 85, p. 369 (1915) et var. *Helmsii* Domin, loc. cit. p. 361.—Affinis *E. mucronatae* R.Br., a qua vaginis infimis dense lanatis, internodiis inferioribus plerumque lanatis, spiculis majoribus, lemmatibus tenuibus conspicue 7-nervibus stramineis emucronatis marginibus ciliatis differt.

*Gramen* perenne, caespitosum, robustum, basi dense lanatum. Culmi validiusculi, ramosi, teretes, adscendentes, plurinodos, plerumque 40–60 cm. alti; internodia inferiora dense lanata, superiora scaberula, omnia nonnunquam glabra; nodus supremus pubescens, ceteri glabri (omnes raro glabri). *Foliorum vaginæ* teretes, laxae, internodiis breviores, basales elaminatae lanatae, ceterae laeves vel scaberulae, apice plerumque pilosae; ligulae breviter ciliatae; laminae lineares, flaccidae vel rigidiusculae, planae vel nonnihil involutae, mox deciduae, 1.5–6 cm. longae et 1–2 mm. latae, scaberulae. *Panícula* linearis vel anguste oblonga, erecta, 3–8 cm. longa; rami appressi, scaberuli; pedicelli graciles, scaberuli. *Spiculæ* biflorae, stramineae vel raro purpurascens. *Glumæ* subaequales, late ovatae, obtusiusculae, membranaceae, 9–11-nerves, 4.5–6.5 mm. longae, glabrae, marginibus latis hyalinis. *Lemmata* lanceolata, acuta vel obtusiuscula, haud mucronata, tenuiter chartacea vel membranacea, conspicue 7-nervia, 5.5–7 mm. longa, infra medium villosa, supra medium ciliata, marginibus hyalinis. *Paleae* anguste lanceolatae, lemmatibus aequilongae, infra medium pilosae.

Western Australia. Wandagee, Minilya River, on red sand, *Gardner* 3287; Roderick River, *Gardner* in 1927; Port Hedland, *Fitzgerald* 45; Meekatharra, watercourse, *Gardner* 2345; Sandstone, *Gardner* in 1927; Wargawal Station, near Wiluna, *Wise* in 1931.

Central Australia. North Musgrave Ranges, *Basedow* 65; near Mt. Hay, *Cleland* L17; Victoria Desert, near Ferdinand River, *Helms* in 1891 (type).

New South Wales. Bourke District, without collector (Mus. Brit.).

Queensland. Near Barcaldine, in dry forest on sandy soil, *Domin* in 1910 (Herb. Domin); Charleville, in railway enclosure, on brown sandy soil, *Hubbard & Winders* 6120.

*Domin* (Bibl. Bot. xx, Heft 85, pp. 359, 361; 1915) described two new varieties of *Eriachne mucronata* R.Br., viz. var. *villiculmis* and var. *Helmsii*, from Queensland and Central Australian specimens respectively, commenting on the latter that it appeared to be a very distinct form and should perhaps be regarded as a separate species (*E. Helmsii*). Study of a wider range of material confirms the view that it is a well-marked species, and I have accordingly taken up *Domin*'s name here with the addition of a complete description, treating his var. *villiculmis* as a synonym.

As here understood, *E. Helmsii* appears to be widely distributed through the mulga country of arid Australia. It has been confused commonly with *E. mucronata*, but can be distinguished readily from that species by the densely woolly base, larger spikelets, and the different structure of the lemmas. In *E. mucronata* the lemmas are somewhat coriaceous in texture, usually purplish, and with inconspicuous nerves. They are pubescent only on the lower half, with little or no marginal fringe or hairs above, and are abruptly obtuse and mucronate at the apex. On the other hand, *E. Helmsii* has more membranous, strongly nerved, yellowish lemmas, with an irregular but distinct ciliate fringe on the upper half and an acute or somewhat erose apex.

Confusion between the two species is particularly apparent in South Australia. Black's description of *E. mucronata* in his Flora of South Australia (p. 71) refers to 'stems... from a woolly base' 'flowering glume... ciliate with long hairs on the marginal nerves almost to the top'—characters which clearly indicate that the species referred to is *E. Helmsii*. On the other hand, the plants described with the 'flowering glume... obtusely mucronate, very villous but not ciliate in the upper part' under *E. ovata* Nees var. *pedicellata* J. M. Black (Trans. Roy. Soc. S. Australia, XLVI, 565; 1922)—part of the type collection of which has been examined—are undoubtedly true *E. mucronata*.

*Eriachne glabrata* (Maiden) Hartley, stat. nov. *E. obtusa* R.Br. var. *glabrata* Maiden in Agric. Gaz. New South Wales, XIX, p. 836 (1908).—Affinis *E. insulari* Domin, a qua habitu gracillimo, culmis brevioribus 2–5-nodibus, panícula minore leviter ramosa, ramis brevioribus validiusculis, lemmatibus appresse pubescentibus haud hirsutis differt.

*Gramen* perenne, gracile, dense caespitosum, innovationibus numerosis. Culmi



gracillimi, teretes, simplices vel leviter ramosi, erecti, 2-5-nodes, 15-30 cm. alti, laeves et glabri. *Foliorum vaginæ* teretes, striatae, internodiis breviores, glabrae sed apice pilosae; ligulae brevissime ciliatae; laminae angustissimae, erectae, arcte involutae, rigidiusculae, 2-4 (raro -8) cm. longae, glabrae et laeves. *Panicula* erecta, primo contracta, demum divaricata, plerumque 2-4 (raro -6) cm. longa; rami distantes, plerumque 3 vel 4, rigidiusculi, inferiores usque 3.5 cm. longi, superiores breviores, asperuli; pedicelli breves, validiusculi. *Spiculae* biflorae, 3-4 mm. longae, plus minusve purpurascens. *Glumae* subaequales, late ovatae, obtusae, membranaceae, 7-9-nerves, 2.5-3.5 mm. longae, glabrae. *Lemmata* ovata, obtusiuscula, tenuiter chartacea, obscure 5-7-nervia, 3-4 mm. longa, fere usque ad apicem dorso breviter appresse pubescentia. *Paleae* ellipticae, tenuiter chartaceae vel hyalinae, lemmatibus aequilongae, infra medium margines versus sparse et minute pubescentes.

New South Wales. Rose Bay, Port Jackson, *Forsyth* in 1898.

Queensland. Beerwah, *Meebold* 7814; Eight Mile Plain near Brisbane, in open Eucalyptus forest on very poor sandy soil, *Hubbard* 2074; near Lawnton, on open sloping damp country, *Blake* 190; Meridan Plains, near Buderim Mt., on wallum flats, *Blake* 5215; Petrie; in a dry Melaleuca swamp, *Blake* 333; Lake Cootharaba, on wet ground, *Keys* in 1910 (Herb. Brisb.); Bribie Island, *White* in 1916 (Herb. Brisb.).

This species, which appears to be confined to the coasts of New South Wales and southern Queensland, was described by Maiden as a variety of *Eriachne obtusa* R.Br., but shows little relationship to that species. It is a much smaller plant, with densely tufted basal shoots, very narrow, rigid, closely involute blades, and much smaller, subracemose panicles. The chief distinctions are, however, to be found in the lemmas, which in *E. obtusa* are very thin in texture, covered on the lower half with long spreading hairs and prominently ciliate all round the upper margins. The lemmas of *E. glabrata* are thicker, shortly appressed-pubescent except at the summit, and not ciliate on the margins. The new species appears to be most closely related to *E. insularis* Domin, a grass known only from Stradbroke and Bribie Islands in southern Queensland.

***Eriachne Dominii* Hartley**, nom. nov. *E. tuberculata* Domin in Journ. Linn. Soc. Lond., Bot. xli, p. 280 (1912); non Nees (Fl. Afr. Austr. p. 274; 1841).

Contributions to the Flora and Phytogeography of south-western Greenland: an enumeration of the vascular plants, with critical notes. By NICHOLAS POLUNIN, Fielding Curator and Keeper of the Herbaria, University Demonstrator and Lecturer in Botany, Oxford. (Communicated by Professor T. G. B. OSBORN, F.L.S.)

[Read 19 March 1942]

'Ask a person who has lived many years in the Arctic and become acclimatized to it, what, if anything, he finds wanting of the ordinary life of his more genial mother country, he will respond that he misses something, sometimes so much that he is heartsick with longing, such things as fresh strawberries, the shade of trees, or good music... It had been the writer's wish for many years to make a trip to southernmost Greenland, that peculiar section, part of a big Arctic land, but not Arctic itself, or rather, with the Arctic keynote modified by a nuance of something more genial. It is a country where trees still are seen; where Eric the Red and his people had their farms, churches and cloisters; and where now their Eskimo victors, their seals having gone, are trying to establish a living by cattle- and sheep-ranching, in the fashion of the old Norse and on their very farm-sites.'

These words of Dr M. P. Porsild (1930, p. 3)<sup>1</sup> so admirably describe the southernmost portion of West Greenland, as well as my own sentiments in visiting this fascinating region, that I make no attempt to supersede his account. I did, however, in the summer of 1937 make an effort to add to the already considerable floristic results which Dr Porsild, aided by two of his sons and a small native crew, had obtained during an expedition there twelve years earlier. And this attempt, long cherished during previous years of arctic travel and research but in the end hastily planned and carried out alone, succeeded far beyond my wildest expectations.

A preliminary report on my chief floristic findings, with brief descriptions of other interesting features, has already been given (Polunin, 1938); also an account of the local birch 'forests' (Polunin, 1937). Noteworthy was the discovery of plants apparently introduced from America by the Norsemen—a subject which is, however, too intricate and full of possibilities for a definite pronouncement to be made until further investigations have been completed. It is accordingly excluded from the present paper, which consists principally of a treatment of the known vascular flora in such detail as has been considered desirable and yet has proved possible.

The area to which my observations were confined was much more limited than that of the Porsilds, as I had not a vessel at my command and in any case believe in the maxim that 'He who looks closest sees most'. With the exception of brief landings made at a few points during a schooner voyage from Ivigtut southwards to Julianehaab, I was confined to the 'Julianehaab district, northern part', as delimited by Porsild (1930, p. 6). The innermost portions of the fjords and valleys of this district and of those occurring to the south-east comprise what is climatically the most favourable region of all Greenland, as was already recognized nearly a millennium ago by Eric the Red and his followers.

This region is, moreover, 'one of the best botanically explored... of Greenland', having been investigated by such a 'long line of well-trained experts' (Porsild, 1930, p. 5) that it 'cannot... be expected to yield anything surprising in a floristic respect' (Seidenfaden, 1933, p. 5). Nevertheless, my optimism and expense in visiting it were amply justified by the floristic results alone. At least eleven species (excluding recent introductions and some doubtful segregates, etc.) were added to the known flora of Greenland, as well as further intraspecific or other minor entities. Another plant new to Greenland was found

<sup>1</sup> For literature referred to in the text by year and page in this manner, see the list at the end of this paper (p. 405).

the same summer in this region by a Dano-Norwegian botanical expedition. If we add to all these the ten or more relatively northern species discovered in 1937 in this most south-westerly region but previously thought to be absent therefrom,<sup>1</sup> although well known elsewhere in Greenland, we find the known vascular flora of this area increased by some 10% in a single brief summer! Excluding the vast majority of recent introductions this flora now appears to consist of 313 certain or probable species, to which considerable quota the rest of Greenland can add perhaps 100.

The following list of localities, dates, and 'collection numbers' assigned to my gatherings at each place, will give some idea of my itinerary. This last can be followed on the map recently published by Dr C. E. Wegmann (in Medd. om Grønland, cxiii, 2, pl. 1; 1938), who also gives the most up-to-date geological account and bibliography of the region. Excluding Ivigtut, my most westerly point of call was Borgs Havn (long. 48° 10' W.) in Kobbermine Bugt, the most easterly being Akuliaruserssuaq (long. 45° 11' W.). In latitude my localities ranged only from Kingua (61° 15' N.) in Tunugdliarfik Fjord to Sydprøven (60° 26' N.) on the 'outer coast'. Where necessary I travelled by boat; otherwise on foot and alone. The distances traversed were small, even having regard to the difficult nature of the country, but those actually walked in search of plants or game or during ecological investigations must have been considerable. In other words, I 'took my time nosing around' and had a grand holiday, for the most part living off the country with the aid of my 0.22 rifle and various fishing contraptions. Heat and mosquitoes were often my chief worry, apart from the knowledge that I must be missing much in spite of all the 'finds'.

Kepisarko (Kipisako), north coast of Kobbermine Bugt (Coppermine Bay)

3 July: coll. nos. 10,000-10,003

Borgs Havn, Sanerut Island, north coast of Kobbermine Bugt

3 July: coll. nos. 10,004-10,005

Josua-Minen, Alangorssuaq Island, south coast of Kobbermine Bugt

4 July: coll. nos. 10,006-10,011a

Qagsimiut (Kagsimiut)

4 July: coll. nos. 10,012-10,031

Julianehaab (first visit)

7-8 July: coll. nos. 10,032-10,180

Sydprøven

12-14 July: coll. nos. 10,181-10,339

Lichtenau (first visit)

15 July: coll. nos. 10,340-10,341d

Akuliaruserssuaq (Akuliarusersuaq)—*cited in the text as 'Akul.'* 16-18 July: coll. nos. 10,342-10,427e<sup>a</sup>

Lichtenau (second visit)

23 July: coll. nos. 10,428-10,455

Qagdlimiut (Kagdlimiut)—*cited as 'Qagdl.'*

26-27 July: coll. nos. 10,456-10,489

Between heads of Agdluitsoq (Lichtenau) and Igaliko Fjords—*cited as 'bet. Agd. & Ig. Fjords'*

30 July-2 Aug.: coll. nos. 10,490-10,644

Gammel Qagsiarssuk (Kagsiarssuk, Kaksiarssuk), Igaliko Fjord—*cited as 'Gl. Qagss.'*

4-8 Aug.: coll. nos. 10,645-10,830

Igaliko (first visit)

10-12 Aug.: coll. nos. 10,831-10,905

South of Qagsiarssuk (Kagsiarssuk) in Tunugdliarfik Fjord—*cited as 'S. of Qag. in Tun. Fj.'*

14 Aug.: coll. nos. 10,906-10,970

Qagsiarssuk (Kagsiarssuk) in Tunugdliarfik Fjord—*cited as 'Qag. in Tun. Fj.'*

15-18 Aug.: coll. nos. 10,971-11,032 & 11,082-11,103a

Kingua (Qingua) in <sup>a</sup> Tunugdliarfik Fjord—*cited as 'Kingua in Tun. Fj.'*

17 Aug.: coll. nos. 11,033-11,081

Kiagtut

20-21 Aug.: coll. nos. 11,104-11,201

Igaliko (second visit)

22-23 Aug.: coll. nos. 11,202-11,315

Between Igaliko and Julianehaab—*cited as 'bet. Ig. & Jul.'*

26-27 Aug.: coll. nos. 11,316-11,365a

Qangerdluarsuk (Kangerdluarsuk)—*cited as 'Qanger.'*

29 Aug.: coll. nos. 11,366-11,380

Julianehaab (second visit)

1 Sept.: coll. nos. 11,381-11,442b

The following is essentially an annotated list of the vascular plants so far known to occur within (or, in a few instances, just outside) the area which I visited. I have kept to

<sup>1</sup> Cf. Devold & Scholander (1938, p. 75). Several familiar arctic species are, however, still unknown from southernmost Greenland. These include *Cassiope tetragona*, *Draba alpina*, and *Potentilla emarginata*, all of which I had fully expected to find in the mountains.

<sup>2</sup> With the exception of a few introduced plants collected at Sletten (see p. 404), where only a very brief call was made.

<sup>3</sup> My specimens from here were distributed as from the 'Head of' Tunugdliarfik Fjord.

the sequence laid out by Porsild (1930), although his nomenclature frequently needed changing, and have added only authenticated recent finds and plants previously reported by reliable authors but overlooked by Porsild: of most of these 'omissions' I have seen specimens. The recent finds are my own or those of the Dano-Norwegian Botanical Expedition of 1937, which was led by Magister Johs. Grøntved of Copenhagen and Cand. Real. Eilif Dahl of Oslo. Species not found by any of us in 1937, but only previously by others, have their names and appended details in square brackets in the list given below. Magister Grøntved published (1938) his own chief finds and some of Dahl's. The latter was kind enough to send me at the British Museum duplicates from most of his more noteworthy gatherings and, as he does not appear to have written them up, I am taking the liberty of mentioning them, with due acknowledgement. The war has now long prevented us all from corresponding and collaborating.

It had been my intention, following the procedure in my 'Botany of the Canadian Eastern Arctic' (Part I, 1940, footnote on p. 23), to make at least some mention of all plants that had been reported from SW. Greenland, however doubtfully or wrongly, and determine wherever possible their true identity, so as to obtain a Flora of the region; but in our present state of segregation from the Continent this is out of the question, as access to the necessary type and other original specimens is impossible. Fortunately most early reports were 'picked up' by Lange (1880 & 1887), Rosenvinge (1892 & 1896), or Porsild (1930), all of them good botanists, and moreover in the vast majority of cases it has been an easy matter to determine just what they meant by the plants they recorded. Accordingly, when I have applied a different name or detected an error, I have generally been able to indicate as much by giving synonyms or adding notes. This is unfortunately not true of certain intraspecific units and groups of critical species (particularly among the apomictic Compositae, a few grasses, and the *Bigelowia-salina* group of Carices), where I have thought it best to omit some of the more doubtful names rather than run a serious risk of putting them in the wrong place. I have also ignored many reports by such authors as Gisecke and Sir Joseph Hooker (because their views and methods were often far removed from those of to-day); and, as implied above, I have ignored almost all records from outside the area visited.

The resultant list is conservative in its treatment of taxonomic entities. Rather than recognize microspecies that seem to me doubtful, or commit myself in a group I do not understand, I have generally preferred to 'lump' under a broader, more inclusive name to which is then appended 'sensu lat.' (sensu lato, vel latissimo). Similarly with polymorphic species I have usually preferred to add the suffix 'aggr.' rather than force my material into doubtfully distinct 'compartments' or erect new ones. There are no new species or entities that can seriously be claimed as such; but there are a few apparently undescribed forms that are so striking as to deserve names.

Some explanation should be given of the method of reporting occurrence. If I found a species plentifully in all or at least most of the localities visited, it is simply described as 'common'. If the species was widespread but less plentiful this may be modified to 'fairly common'. If it seemed markedly less frequent, according either to Porsild's indication (1930) or to my own experience, I usually give a list of localities (noted as 'additional' or 'new') in which I found it. Further details of occurrence must await a far more thorough investigation of the area than has yet been attempted. Meanwhile, I trust that no earlier author or collector will take it amiss if I have omitted to mention or imply that I have not seen some of his records or material; I spent many days and nights checking everything that I could, but not always under the best conditions and with all the necessary literature at hand. Apart from undescribed collections, for whose consideration in the present state of the world personal responsibility cannot be felt, omissions are especially liable to occur when an author has given only a general locality, e.g. Tunugdliarfik Fjord, in which case, in the absence of specimens or other indication of the *precise* locality, I have given my own as 'additional' if the plant was noteworthy or rare enough

to warrant it. Yet another possible source of confusion are the Greenlandish place-names: these may have alternatives, or have been changed or superseded—such complications being especially frequent in inhabited places where Danish as well as Eskimo is used.

As to what is meant by 'locality', it is generally a known and named spot and its immediate environs, say, within a radius of 4 or 5 kilometres. But sometimes it is rather more vague, e.g. the head of a fjord, or somewhere in a long and wide valley, or at a place which as far as I could determine had no name and had accordingly to be given some directional designation relating it to a known place. In two instances the localization is even less satisfactory:

(1) 'Between heads of Agdluitseq and Igaliko Fjords' (usually contracted to 'bet. Agd. & Ig. Fjords'), when I went from Qagdlimiut overland to Gammel Qagssiarssuk—a distance of only about 30 kilometres though I probably walked three or four times this while exploring and collecting on the way, and

(2) 'Between Igaliko and Julianehaab' (usually contracted to 'bet. Ig. & Jul.'), which is farther but easier going, and where I climbed, having a light pack, and hunted extensively.

Finally, we come to what ought perhaps to have been put first—my great indebtedness and warmest thanks to Mr A. J. Wilmott, Deputy Keeper, Department of Botany, British Museum (Natural History). When the Museum was badly damaged through enemy action in the autumn of 1940, the whole of the collection on which this contribution is based, which was still in 'drying' paper, was soaked through with water. But the specimens were so quickly and skilfully dried that apart from a very few which had been slightly charred they were none the worse for the experience. Mr Wilmott subsequently with a band of helpers divided the collection into three lots for safety, the 'first set' being retained (as originally arranged) by the British Museum in return for their generous support of my expedition, for which Dr J. Ramsbottom and the Trustees are to be sincerely thanked, the 'second set' being labelled according to my original determinations made in the Botanical Museum at Copenhagen and sent to me at the Fielding Herbarium, Department of Botany, Oxford, and the remainder being sent to another Oxford institution which is in my care, and whence several extensive series of duplicates will in time be available for distribution. This premature separation into lots and their geographical segregation in the interests of safety has naturally complicated my task of revising labels and citing specimens; but it need not, I trust, be invoked as an excuse for errors in the present report, whose preparation was already well advanced when the bombing occurred. More serious than the physical impossibility of finally comparing and checking all of the material together when once it had been thus divided was the difficulty of consulting large parts of the British Museum and Kew herbaria and libraries after their evacuation.

Not content with all the invaluable services mentioned above and rendered in times of extreme stress and national emergency, Mr Wilmott subsequently gave me much assistance in improving various parts of the present paper; his great knowledge of the European flora has been instrumental in solving many of the worst problems, and he has given unstintingly of it on numerous occasions.

Other experts—and there are many—to whom I am indebted for opinions or helpful criticisms or advice are mentioned in appropriate places in the text.

Here, however, I would like to thank Magister Johs. Grøntved for the hospitality of his expedition during the schooner voyage between Ivigtut and Julianehaab, as well as ashore at the latter place. I also have the happiest memories of my visits to other inhabited places, at every one of which I was treated with great kindness and consideration. Good friends who remain fresh in my memory are the chiefs at Sydprøven, Sletten and Igaliko, and their families, the 'king' at Igaliko, Pastor Lynge at Lichtenau, the native catechist at Qagssiarssuk in Tunugdliarfik Fjord, and the only family then resident at Gammel Qagssiarssuk. I also wish to thank Andreas Egede of Igaliko Fjord for hospitality and guidance across an ice-cap river, and particularly Hans Lynge (Napartoq) of Julianehaab for many kindnesses; also Dr C. E. Wegmann of Schaffhausen, Switzerland, for putting his large motorboat at my disposal on two occasions when leaving Julianehaab.

(The abbreviations of place-names which occur in the following pages are explained on p. 350)

### POLYPODIACEAE

*WOODSIA ILVENSIS* (Linn.) R.Br. — Common.

[*WOODSIA ALPINA* (Bolton) S. F. Gray (*W. hyperborea* R.Br.) — Omitted by Porsild (1930) and not seen by any of us in 1937, but reported from the area by Lange (1880, p. 189) and confirmed by Rosendahl (1918, p. 213).]

*WOODSIA GLABELLA* R.Br. — New to SW. Greenland when found in 1937 in two localities by the Dano-Norwegian expedition—see Grøntved (1938, p. 254). I have seen Dahl's specimens from Kiagtut and they appeared quite typical.

*CYSTOPTERIS FRAGILIS* (Linn.) Bernh. — Common. As usual very variable in size and general appearance.

*CYSTOPTERIS MONTANA* (Lam.) Bernh. — Refound (nos. 11145, 11159) in the Porsilds' original locality, S. of Kiagtut. Said to grow also in other places in the Julianehaab district, one of which has been confirmed by Grøntved (1938, p. 253).

*DRYOPTERIS FILIX-MAS* (Linn.) Schott (*Lastrea Filix-mas* (Linn.) Presl) — Fairly common.

*DRYOPTERIS SPINULOSA* (Muell.) Kuntze var. *americana* (Fisch.) Weatherby — see Porsild (1930, p. 8). Common, and varying considerably. Mr A. H. G. Alston kindly verified my determinations, but remarked that some of the specimens were far from typical—cf. Devold & Scholander (1933, p. 21), who indicate that a revision is needed of the Greenland plants belonging to this group.

*DRYOPTERIS PHEGopteris* (Linn.) C.Chr. (*Polypodium Phegopteris* Linn.) — Common.

*DRYOPTERIS LINNAEANA* C.Chr. (*Polypodium Dryopteris* Linn.) — Common. Mr C. V. Morton (in *Rhodora*, XLII, pp. 216 et seq.; 1941) advocates the use of the name *Dryopteris disjuncta* (Rupr.) Morton for this form.

*POLYSTICHUM LONCHITIS* (Linn.) Roth (*Aspidium Lonchitis* (Linn.) Sw.) — Said to be common, but I did not see it at all frequently. It seemed, however, to be quite plentiful at Qagd. and at the foot of Akul.

[*ATHYRIUM* — None collected; see Porsild (1930, p. 9), and Devold & Scholander (1933, pp. 18–19).]

*ASPLENIUM VIRIDE* Huds. — Not found by me, but I have in Oxford specimens taken the same summer by Eilif Dahl of the Dano-Norwegian expedition in Arsuk Fjord, where it was collected long ago by Nathorst (cf. Lange, 1887, p. 305).

### OPHIOGLOSSACEAE

*BOTRYCHIUM LUNARIA* (Linn.) Sw. — Common. Sports that more or less conform to Porsild's description (1930, p. 9) of his 'monstrous form with sporangia on upper parts of the sterile fronds' are not infrequent; a closer search at Gl. Qagss., Igaliko Fjord, also revealed specimens: (i) with one or more smaller fertile 'branches', either arising in the

'axil' of the sterile 'branch' or else replacing the lowest pinnac of the latter; (ii) with the margins of the lowest or other pinnae bearing a few sporangia, generally in a single row; (iii) with a combination of two or more of the above-mentioned features.

As was kindly pointed out by Prof. T. G. B. Osborn, most of these as well as some other extreme conditions are already known (see Goebel, *Organographie d. Pflanzen*, ed. 3, II, pp. 1234, 1264; 1930).

**BOTRYCHIUM BOREALE** Milde — Apparently rare. Additional localities: Qag. in Tun. Fj. (no. 11028); Kiagtut (no. 11112). From the latter place comes also no. 11113, which in some characters is reminiscent of *B. Lunaria*, and may possibly represent a hybrid with that species (cf. Holmberg, *Hartmans Handb. i Skand. Fl.* I, p. 33; 1922). It was growing among plants of *B. Lunaria*, *B. boreale*, and *B. lanceolatum*, which indeed were several times found all together.

A single plant in the Arctic Herbarium of the Botanical Museum at Copenhagen, collected to the south-east of our area by Jens Vahl more than a century ago and labelled 'Aug. 1829 in locis graminosis sinus Tasermiut 60° 5'', was determined by Gelert as *B. simplex* Hitchcock and included by him as such in Ostenfeld's 'Flora Arctica' (1902, p. 3). It is the sole source of all subsequent reports of *B. simplex* from Greenland and 'the Arctic', but actually belongs to *B. boreale*. Indeed, this is already clear from the illustration (indifferent!) of Vahl's specimen in Ostenfeld's 'Flora Arctica', which shows a branched and bushy fertile part of the frond, and, as an only character suggesting *B. simplex* (apart from a lamina which is misrepresented, being in the original specimen much more markedly pinnate), a rather low point of origin (a little less than half-way up) for the sterile part. However, this is a very variable character in *B. boreale*, which Milde (in *Nova Acta Acad. Caes. Leop.-Carol. Nat. Cur.* xxvi/2, p. 758; 1858) says has 'steriler Wedeltheil ungestielt, in der Mitte der Pflanze oder etwas darüber erscheinend'. It is an even more variable character in *B. simplex* (cf. Robinson & Fernald (*Gray's New Man. Bot.* ed. 7, p. 48; 1908) who say 'sterile segment short-petioled from near base, middle, or summit of the stalk'), which, as agreed by Dr Thorv. Sørensen and Mag. Gunnar Seidenfaden of Copenhagen, is for the time being to be excluded from the Greenland list.

**BOTRYCHIUM LANCEOLATUM** (Gmel.) Ångstr. — Less rare than has been suggested, and indeed quite frequent in some localities, of which the following two are new: Julianehaab (nos. 10055, 10172a); bet. Agd. & Ig. Fjords (no. 10595). It may be noted that I have written the last author's name in the usual manner, for, 'not being part of the scientific name, [it] is not necessarily Latin in form' (J. E. Dandy, in lit.).

**BOTRYCHIUM TENEBROSUM** A. A. Eaton in Fern Bull. VII, p. 8, 1899 (*B. simplex* Hitchc. var. *tenebrosum* (A. A. Eaton) Clausen) — New to the Flora of Greenland. This little-known plant was found only at Kiagtut, no. 11111. This name in Greenlandish means 'the warm place', a fact that is all the more significant in a district which is probably the most favourable in all Greenland; thus the opposite bank of Tunugdliarfik Fjord was chosen for his estate, after a long search, by the pioneering Eric the Red. The plant is evidently extremely rare in Greenland, where indeed it may well be limited to the general vicinity of my one 'find'. This consisted of about three dozen individuals growing in an open place in the birch 'forest', mixed with plants of all the three other Greenland species of *Botrychium*, and stretched over an area of about 50 square metres of dry sandy soil supporting a poor community of mixed grasses, Carices, and lichens—a habitat very different from 'the dark shady places in which the plant characteristically grows' (to quote Clausen in *Mem. Torrey Bot. Club*, xrx, p. 77; 1938).

The specimens as a whole are highly characteristic, but they exhibit some degree of variation amongst themselves in such characters as (i) the length of the 'petiole' of the sterile part of the frond, (ii) the degree of branching of the fertile part of the frond, and

(iii) the shape of the pinnae. These last in some of my specimens are rather reminiscent of those of *B. simplex*, a species which has to be excluded from the Greenland flora (see above).

Although no specimens of *B. tenebrosum* from elsewhere are available for comparison, my material agrees so well with the figures and account given, for example, by Clausen (in Mem. Torrey Bot. Club, xix, pp. 75, 77; 1938), that there can be practically no doubt as to the correctness of the determination: Mr A. J. Wilmott, whom I asked to examine the specimens, made the same identification independently. Clausen (in tom. cit., p. 78) gives the distribution as 'Quebec and southern Ontario south to northern New Jersey, northern Pennsylvania, and Michigan; Minnesota; Washington; and Austria'. He found it impossible to consider *tenebrosum* as an entity higher in status than a 'decidedly distinct variety' because it 'occurs at various places throughout the entire range of the *B. simplex* complex'; now, however, its occurrence in an apparently isolated situation in far-off Greenland, added to its morphological *differentiae*, suggests that it should indeed be maintained as a distinct species in the manner originally described—cf. also the excellent photograph given by Waters (Ferns Northeastern States, p. 325; 1903) and the account of Underwood and Benedict (N. Amer. Fl. xvi, p. 5; 1909). My material was originally identified as a reduced form of *B. matricariaefolium* A.Br., and unfortunately in first reporting it I wrote (1938, p. 90) '*matricarioides* A.Br.' *B. tenebrosum* has indeed been placed by others as a variety of *B. matricariaefolium* 'on the erroneous assumption that...[it]...represents a depauperate form of *B. matricariaefolium*, but such forms of the latter are not at all like *tenebrosum*' (Clausen, in tom. cit., p. 77).

## EQUISETACEAE

*EQUISETUM ARVENSE* Linn. — Common. As usual extremely variable in habit and size (cf. Polunin, 1940, p. 33).

*EQUISETUM SYLVATICUM* Linn. var. *pauciramosum* Milde — see Porsild (1930, p. 10). No new localities.

*EQUISETUM TRACHYODON* A.Br. — Found by me twice, growing in fair abundance in adjacent bogs at Gl. Qagss. in Igalko Fjord (nos. 10675, 10689), but still known from nowhere else in Greenland. It is sometimes considered to be the hybrid *E. hyemale* × *E. variegatum* (cf. Hegi, Illustr. Fl. v. Mittel-Europa, vii, pp. 147–8, 1931, and Holmberg, Hartmans Handb. i Skand. Fl. i, p. 42, 1922; but contrast Schaffner in Amer. Fern Journ. xx, p. 101, 1930). However, it should be noted that *E. hyemale* appears to be absent from Greenland, even if it may conceivably have occurred there during a post-glacial warm period (cf. Polunin, 1937, p. 939). As has been pointed out by Porsild (1932, p. 42), this plant from Gl. Qagss., previously found only by Rosenvinge in 1888 and published by him (1892, p. 741) as '*E. hiemale* var. *Doellii*', is in reality *E. trachyodon*—see also Schaffner (in Amer. Fern Journ. xx, pp. 100–1, 1930) who already remarks: 'The reported specimens of *E. hiemale* in southwestern Greenland appear to be *E. trachyodon* which may have been transported by the Norsemen.'

Until quite recently *E. trachyodon* had been reported only from Europe (including the British Isles—see Matthews in Trans. Bot. Soc. Edinb. xxxiii, pp. 29–32; 1940); but specimens of it are to be found in the American material of almost any good herbarium. Examples of such specimens are: O. A. Farwell, Shores of Belle Isle in Detroit R., Mich., June 4, 1895, no. 211a sub nom. *Hippochaete hyemalis* (Linn.) Farw. var. *Jesupi* (A. A. Eaton) Farw. in Herbs. British Museum and Copenhagen, and G. C. Druce, Glacier House, Canada, June 1908, sub nom. *Equisetum hyemale* in Herb. Fielding, Oxford; cf. also Schaffner (in Amer. Fern Journ. xxi, pp. 99–101, 1931, and xxii, p. 125, 1932). According to the label of Rosenvinge's specimen in the Arctic Herbarium at Copenhagen,



it would appear that he at first identified the plant correctly but later revised his decision, his subsequent report of *E. hyemale* being the source of the oft-repeated citation of that species from Greenland.

*EQUISETUM VARIEGATUM* Schleich. — Common in most places but certainly not everywhere. My nos. 10702 and 10783a, both from Gl. Qagss., are superficially very reminiscent of *E. palustre*, which has not been found in Greenland but whose range elsewhere suggests that it may occur there.

[*EQUISETUM SCIRPOIDES* Michx. — Not seen. Not mentioned by Porsild (1930, cf. pp. 9–10), but cited by Ostenfeld (1926, p. 54) as occurring in the extreme south of Greenland—i.e. south of 61° N. Since it is excluded by Seidenfaden & Sørensen (1937, cf. p. 170) from the flora of East Greenland, the suggestion is that Ostenfeld had seen a specimen from within or near our area, where indeed the species is to be expected even if there is as yet no fully authenticated record. Actually, it was long ago reported from our area by Lange (1880, p. 191), but this too would seem to need confirmation, being apparently discounted by Rosendahl (1918, cf. p. 217). It is impossible at present to determine (i) whether Ostenfeld's citation was based merely on Lange's report, and (ii) whether the latter was correct.]

### LYCOPODIACEAE

*LYCOPODIUM SELAGO* Linn. — Common. Represented by f. *appressum* (Desv.) Gelert in exposed places on mountains—e.g. no. 10403 from 1300 m. (4265 ft.) on Akul.

*LYCOPODIUM ANNOTINUM* Linn. — Common. Chiefly, according to the *differentiae* given by Fernald (Rhodora, xvii, p. 124; 1915) var. *alpestre* Hartm. (var. *pungens* of many authors). What appears to be true var. *pungens* (La Pyl.) Desv., or at least material closely approaching it, occurs in some of the most favourable situations. Frequent intermediates are found, however, and characters normally given for the separation of the two forms may actually be seen on different parts of the same plant.

*LYCOPODIUM ALPINUM* Linn. — Common.

*LYCOPODIUM COMPLANATUM* Linn. — Apparently uncommon in the Julianehaab district. Seen once or twice early in my travels but not collected; later on Eilif Dahl kindly sent me specimens from Sletten and Qordlortorsuaq in Agdluitsioq (Lichtenau) Fjord. A detailed account of the Greenland forms and occurrence of this species is given by Porsild (1935, pp. 18 et seq.).

*LYCOPODIUM CLAVATUM* Linn. — Additional localities: Qagd. (no. 10473); bet. Agd. and Ig. Fjords (seen several times); Gl. Qagss. (no. 10765); S. of Qag. in Tun. Fj. (no. 10933).

### SELAGINELLACEAE

*SELAGINELLA SELAGINOIDES* (Linn.) Link (*S. spinosa* P. de Beauv.; *S. spinulosa* A.Br., not Spring) — Previously much overlooked in Greenland (Lange, writing in 1880 (p. 183), knew of it only from Igaliko Fjord), but actually in the Julianehaab district it is common almost everywhere in the middle- and inner-fjord zones, so that in spite of its diminutive size I collected or noted it on more than a score of separate occasions.

### ISOETACEAE

*ISOETES ECHINOSPORA* Dur. — Although Lange (1880, p. 185) gave it as 'meget sjelden', the Greenland plant to which the above name is usually applied is not uncommon in suitable localities, of which the following are additional to those so far published:

Lichtenau (no. 10449); S. of Qag. in Tun. Fj. (no. 10949); Kingua in Tun. Fj. (no. 11040). It was already reported in a subsequent paper by Lange (1887, p. 304) from Tunugdliarfik Fjord, but without any precise locality; the same author's report (loc. cit.) from Agdluitsq Fjord cannot however have had reference to Hartz's specimen collected later at Sydprøven (see Rosenvinge, 1892, p. 738), where I found it again. According to Pfeiffer (Ann. Missouri Bot. Gard. ix, p. 154; 1922) the distribution of *I. echinospora* is 'British Isles, northern and central Europe', the Greenland plant being referable instead to *I. Braunii* Dur. However, Professor Osborn and Mr F. Ballard both doubt whether this should be maintained as a separate species—cf. also Donat in Pflanzenareale, III, p. 93 and map 78; 1933.

[*ISOETES LACUSTRIS* Linn. — Not seen. Not mentioned by Porsild (1930, cf. p. 10), and not known from the more restricted area in which I travelled. There is, however, a specimen in the Arctic Herbarium, Copenhagen, from the area which Porsild considered ('leg. E. Lundholm, Ilua 59° 55' 1891'). It was first determined as '*I. echinospora*', but was recognized by Ostenfeld to be *I. lacustris* as early as 1897, and was so cited by him (1926, p. 54) as well as by Rosendahl (1918, p. 220).]

### CUPRESSACEAE

*JUNIPERUS COMMUNIS* Linn. — Common. Most of the material is referable to var. *nana* (Willd.) Loud. (*Juniperus sibirica* Burgsd., *J. alpina* S. F. Gray), but sometimes in sheltered situations even quite high on the mountains or out on the coast there are to be found plants having a looser habit and longer leaves, and thereby approaching the typical form—e.g. no. 10263 from Sydprøven, where, owing to fuel-gatherers, few individuals were to be seen.

### SPARGANIACEAE

*SPARGANIUM HYPERBOREUM* Laest. apud Beurl. (*S. submuticum* (Hartm.) Neum.) — Common, and, like many of the plants mentioned below, of such general occurrence in the region traversed that it seems unnecessary to list 'new' localities.

*SPARGANIUM ANGUSTIFOLIUM* Michx. 1803 (*S. affine* Schnitzl. 1845—see Bennett in Journ. Bot. LIX, p. 235; 1921: Fernald in Rhodora, xxiv, p. 30; 1922: and Mansfeld in Fedde, Repert. Sp. Nov. XLV, p. 208; 1938)) — So much rarer than the last species that it was not seen by the Porsilds anywhere during their extensive southern trip. Apparently limited to the warm fjordhead regions, in which are situated the following additional localities: Gl. Qagss. (no. 10714); S. of Qag. in Tun. Fj. (no. 10934); Qag. in Tun. Fj. (no. 11027).

### POTAMOGETONACEAE

*POTAMOGETON FILIFORMIS* Pers. (*P. marinus* of authors, not Linn.) — Common throughout the region traversed. Most of the Greenland material that I have seen has the inflorescence short, and so belongs to or at least approaches the usual northern (but none too well defined) var. *borealis* (Raf.) St John; this last may indeed, as Mr J. E. Dandy remarks (in lit.), be 'just *P. filiformis*', but it raises again the question of what taxonomists should do with ecads which have distinguishable ranges that are climatically determined.

*POTAMOGETON BERCHTOLDII* Fieb. (*P. groenlandicus* Hagstr.; *P. pusillus* of authors, not Linn.) — Apparently rare in this district, as it was not seen by the Porsilds during their southern expedition, and by me was found only in two pools a few kilometres apart at Gl. Qagss. (nos. 10768, 10779)—unless a note which I made about finding it at Qag. in Tun. Fj. (where in the field I thought I could detect four or possibly five species besides *P. filiformis*) be substantiated (there are unfortunately no specimens). Messrs J. E. Dandy and G. Taylor, who have been kind enough to examine my material critically, advise

the application of the above name to the present species, in spite of Dr J. Iversen's contentions expressed to me in Copenhagen that it should be maintained as a species distinct from '*P. pusillus* Linn.', to which it had already been reduced by Fernald. As for the familiar name *P. pusillus* Linn., Messrs Dandy and Taylor consider that it must be applied to the plant formerly known as *P. panormitanus* Biv.

POTAMOGETON ALPINUS Balb. (*P. rufescens* Schrad.) — Additional localities: S. of Qag. in Tun. Fj. (no. 10942 fruiting); Kiagtut (no. 11201 flowering, etc.). In the opinion of European experts *P. alpinus* is a circumboreal species that includes *P. tenuifolius* Raf.

POTAMOGETON GRAMINEUS Linn. (*P. heterophyllus* Schreb.) — Rather frequent, and so variable in vegetative characters and general appearance that I was relieved to have the unqualified assurance of Dr J. Iversen, who has made a special study of the Greenland Potamogetons, that my ten collections all belong to this species. Additional localities: bet. Agd. & Ig. Fjords, quite plentiful; S. of Qag. in Tun. Fj., seen several times; Qag. in Tun. Fj. (no. 10980).

POTAMOGETON NATANS Linn. — New to Greenland—cf. Polunin (1938, p. 90). This notable find was made a few kilometres inland of Gl. Qagss. (no. 10706), where the species formed extensive beds in shallow water around the margin of a large lake. It was not encountered anywhere else and, being more noticeable than any of the other Greenland Potamogetons and moreover perfectly distinct, must be very rare even in this most favourable district. In the 'Arctic Herbarium' at Copenhagen are plentiful specimens from Iceland, the Faeroes and Fennoscandia.

## JUNCAGINACEAE

TRIGLOCHIN PALUSTRIS Linn. — Quite common.

## GRAMINEAE

ANTHOXANTHUM ODORATUM Linn. — Common.

HIEROCHLOE ALPINA (Sw.) Roem. & Schult. — Common. This is the *Holcus alpinus* of Swartz ex Willd., 1806 (!) and the *Aira alpina* of Liljeblad, 1792, but not that of Linnaeus, 1753.

HIEROCHLOE ODORATA (Linn.) P. de Beauv. 1812 (*H. borealis* (Schrad.) Roem. & Schult. 1817) — This beautiful grass was found twice during the summer around Sermilik Fjord by the 1937 Dano-Norwegian Botanical Expedition (cf. Grøntved, 1938, p. 253). I have also seen in the Arctic Herbarium at Copenhagen a scrap which unmistakably belongs to this species, to which it was indeed referred by Lange (cf. 1880, p. 157), although he doubted its authenticity. The label reads '*Holcus alpinus* Godhavn Grønlands. Giesecke', but then Godhavn is crossed out and '*Christianehaab*' substituted in the same hand. The specimen is also noted as '*ex Herb. Hornemannii*'. It seems highly probable that it came from Greenland after all; but since there is some doubt about this, and especially about the locality, Grøntved's definite record is at least as valuable as if it had represented an entirely and indubitably new find.

PHLEUM ALPINUM Linn. — Common; and, as usual, very variable.

ALOPECURUS AEQUALIS Sobol. 1799 (*A. aristulatus* Michx. 1803, *A. fulvus* Sm. 1805) — Fairly frequent. Additional localities: Sydprøven (no. 10256); bet. Agd. & Ig. Fjords (no. 10580).

*ALOPECURUS PRATENSIS* Linn. — Abundant and seemingly well established on several of the ruins on Eric the Red's estate Brattahlíð at Qag. in Tun. Fj. (nos. 10999, 11093), and said by Otto Fredericksen, the first modern settler in this place, to have been so when he arrived there about 1912. Hence presumably an 'Old Norse' introduction, even if the other specimens from Greenland (e.g. my nos. 10435 from Lichtenau and 10378 from Sletten near Akul.) belong to more recent stock (cf. Rosenvinge, 1892, p. 728, and Porsild, 1932, p. 9).

*AGROSTIS STOLONIFERA* Linn. (*A. alba* of authors, not Linn.) — Very variable. Frequent and indeed almost general, although it still seems worth noting the following 'additional' localities: Julianehaab (no. 10174); Qag. in Tun. Fj. (no. 11006); Kingua in Tun. Fj. (no. 11073). Rosenvinge's '*Agrostis alba*...monstr. *longepaleacea*' (1892, p. 729) is dealt with below, under *Agrostis canina*.

*AGROSTIS GIGANTEA* Roth (*A. nigra* With.) — New to Greenland—cf. Polunin (1938, p. 90). Collected at Igaliko (no. 11241); bet. Ig. and Jul. (no. 11365); S. of Qag. in Tun. Fj. (nos. 10927, 10929); Qag. in Tun. Fj. (no. 11099). My determinations were kindly checked by Dr O. Hagerup of Copenhagen and Mr C. E. Hubbard of Kew in 1937, and finally by Mr W. R. Philipson of the British Museum following the appearance of his recent monograph of the British species of *Agrostis* (in Journ. Linn. Soc. Lond. LI, pp. 73–151; 1937). All these gentlemen assured me of the correctness of my suspicions that this plant has 'nothing to do with' the better-known complex to which it is generally referred, viz. *A. stolonifera*, but represents a perfectly distinct species. It is indeed remarkable that it has not previously been recognized in Greenland, though I found a single culm nearly 1 m. high, with inflorescence 20 cm. long, in the Arctic Herbarium at Copenhagen labelled 'Kakortok Kirkeruin, legít K. N. Christensen 25/10/1925', and determined by the late Prof. Ostenfeld as *A. alba*. This specimen came from our area, where, indeed, I encountered the species on such numerous occasions around the heads of Igaliko and Tunugdliarfik Fjords that it became quite a familiar sight. It had the appearance and habitat rather of a *Calamagrostis*, being not at all tufted but having soft sheaths from which the culms stood stiff and erect and 60 cm. to 1 m. high. It grew generally in open areas in willow or birch scrub, often far from ruins and forming an almost pure stand on sunny, south-facing slopes that were well drained but nevertheless not too dry.

*AGROSTIS CANINA* Linn. — Common; supposedly all belonging to this species, although my specimens have larger glumes (1.8–2.7 mm. long) than is usual in British plants. However, Mr C. E. Hubbard has kindly verified my determinations, while it should also be noted that according to Philipson (op. cit., p. 80) the glumes of this species may vary from 1.5 to 4 mm. in length. I also found the var. *pallida* Reichenb. at Gl. Qagss. (nos. 10770, 10820).

In many places there occurred an aberrant form with dense and strict panicles and proliferation in the spikelets. These abnormalities vary in intensity from plant to plant and particularly from stand to stand, as does also the breadth of the leaves, especially in the sheathing part. They probably result from attacks by the nematode *Anguillina agrostis* (Steinbuch) Goodey in the manner described by Philipson (in Journ. Bot. LXXIII, pp. 66–7; 1935). At first I thought that these peculiar plants, which were obviously not functionally viviparous, and which characteristically grew among other small grasses (including typical *Agrostis canina*) in pastured meadows on light sandy soil near the sea, might represent a dry-land phase of *A. stolonifera*, especially since no awns were visible.<sup>1</sup>

<sup>1</sup> Cf. also Rosenvinge (1892, p. 729), who was clearly describing the same plant when he wrote '*Agrostis alba* L...monstr. *longepaleacea*l, var. *vivipara* Rehb. Ic. Fl. Germ. I fig. 1434; palea inferior valde elongata usque 7 mm. longa, fructus abortivus. Fandtes ved Igaliko paa et fugtigt sted (!) Obs. Forma haec vivipara non est; differt a f. normali praecipue palea inferiori in corpus concium valde elongata, marginibus convolutis. Glumae nonnunquam paullo elongatae.'

But then I found specimens with some non-proliferous spikelets having anthers and glumes like the circumrescent *A. canina*, to a probable pathologic state of which I now feel inclined to refer this form, pending further observation. In this I am supported by Mr C. E. Hubbard, who has recently noted that my specimens all lack lemmata and have the anthers of typical *A. canina*. The following specimens of this 'state' are to be seen in the Arctic Herbarium at Copenhagen and illustrate some more of the difficulties which it has caused for taxonomists: (1) 'Dr. L. Kolderup Rosenvinge 1888, 30 Jul. Fugtigt sted ved Igaliko, *Agrostis alba* L. monstr. *phyllantha*'; (2) 'Aira alpina in locis subhumidis Kaksarsuk sinus Igaliko 1828 Aug.' (J. Vahl) revised as 'Monstrositar vivipara *Festuca ovina* v. *F. rubra* videtur, nec. Aira J. L[ange] 1876' and then 'potius *Agrostis*'; (3) 'A. E. and M. P. Porsild, Qagssiarssuk, Igaliko Fjord, 60° 53' N. 5 Aug. 1925 *Agrostis stolonifera* var. *vivipara*', later given as '?Obs. cf. *Calamagrostis Holmii*'. I myself made the following collections in 1937: Akul. (no. 10410); Gl. Qagss. (nos. 10687, 10712, 10739, 10762); Igaliko (nos. 10857, 10890, 11304); Kingua in Tun. Fj. (no. 11071). The same rather problematical little plant apparently occurs in SE. Greenland (see Devold & Scholander, 1933, p. 133), and possibly also in eastern North America (see Eames in *Rhodora*, xi, p. 88, 1909, sub nom. *A. borealis* var. *macrantha*, and cf. Fernald, 1933, p. 205). Similar phases (e.g. the so-called *A. sylvatica* Huds.) have long been known in Britain (cf. Philipson in *Journ. Bot.* LXXIII, pp. 65 et seq.; 1935).

*AGROSTIS BOREALIS* Hartm. — Common. This and the last species are both very plentiful in the region; both ascend the mountains to considerable altitudes. They are extremely variable and not always to be distinguished from one another (cf. Rosenvinge, 1892, p. 728), at least on the characters given in the floras, and would accordingly seem to require further study in SW. Greenland. Even the very short anther in *A. borealis* appears to be typical rather than infallible—cf. Lange (1887, p. 295), who, like other authors of his time, reported this species under the name *A. rubra* Linn.

*AGROSTIS TENUIS* Sibth. 1794 (*A. vulgaris* With. 1796) — Igaliko (nos. 10870, 10889). New to the flora of Greenland—cf. Polunin (1938, p. 90); Hooker's report (in *Trans. Linn. Soc. Lond.* XXIII, p. 307; 1861) of this species from Greenland was based on an error (see Lange, 1880, p. 159). The plants of no. 10889 were growing luxuriantly in a dampish depression in the pastured homefield at Igaliko, well away from the present settlement and the ruins of the cathedral, but near some *Vicia Cracca* (q.v.) and looking similarly well established. No. 10870 was also growing outside the present-day settlement. Like the *Vicia*, *Agrostis tenuis* was probably introduced by the Norsemen in or around the eleventh century from Iceland, where it is plentiful (e.g. in the valley from which Eric the Red came, as I noted during my visit there in 1938). The determination of no. 10889 was kindly verified by Dr Thorv. Sørensen and Conservator Wiinstedt of Copenhagen, and by Mr W. R. Philipson of the British Museum. No. 10870, originally labelled *A. canina*, was recognized, only much later, by Mr C. E. Hubbard of Kew, who found in it one culm which he labelled '*Agrostis tenuis* × *A. canina*: no palea, lemma awnless, 5-nerved, ligule truncate'. This hybrid is also, apparently, new to Greenland.

*CALAMAGROSTIS CANADENSIS* (Michx.) P. de Beauv. var. *scabra* (Presl) Hitchcock (*C. phragmitoides* of authors; *C. hirtigluma* Steud.—see Inman in *Rhodora*, xxiv, p. 143, 1922, and Chase in *Amer. Journ. Bot.* xxiv, p. 34, 1937; *C. canadensis* var. *Langedorffii* of authors, not *Arundo Langedorffii* Link—see Hitchcock in *Amer. Journ. Bot.* xxi, p. 135, 1934) — Common. I follow Stebbins (in *Rhodora*, xxxii, pp. 39–40 & 43–44; 1930) in referring the SW. Greenland material of this polymorphic species to the usual northern variety, although not always without hesitation as the spikelets are often barely 4 mm. long and sometimes so shaped as to be more suggestive of var. *robusta* Vasey or even of the typical form. All stages of transition to this last occur farther west and southwards on the mainland of North America (cf. Polunin, 1940, p. 52), which makes the usual retention of the

(already variable) Greenland material as a separate species ('*C. Langsdorffii* (Link) Trin.', cf. Devold & Scholander, 1933, p. 135) as inadvisable taxonomically as it is erroneous nomenclaturally (according to Hitchcock, loc. cit.).

*CALAMAGROSTIS INEXPANSA* 'A. Gray, N. Am. Gram. & Cyp. I, no. 20, 1834' (*C. hyperborea* Lange, 1880; *C. confinis* of authors, not *Arundo confinis* Willd.—see Chase (in Amer. Journ. Bot. xxiv, p. 34; 1937), who also excludes *Calamagrostis hirtigluma* Steud. from the synonymy of the present species) — Local, or at least not generally common. The earlier name *C. confinis* (Willd.) Nutt., which has been applied to Greenland material of this species, has not been adopted here because it has been impossible to study the original type specimen, which Chase (loc. cit.) already implies belongs to a different species. I have accordingly followed Hitchcock (N. Amer. Fl. xvii, pp. 513–14; 1937) in using the above name and in separating the present from the next very closely related species, although some of the characters (e.g. the length of the ligule) do not always 'hold'. In this I have been kindly advised by Mr C. E. Hubbard, who has confirmed the following gatherings from among my material: bet. Agd. & Ig. Fjords (no. 10586); Gl. Qagss. (nos. 10728, 10747).

*CALAMAGROSTIS NEGLECTA* (Ehrh.) Gaertn. et al. (*C. stricta* of authors, and incl. *C. neglecta* var. *borealis* (Laestad.) Kearney) — Evidently not uncommon, but so often confused with the last or other species that a critical study of the whole group seems necessary. Such confusion may well account for Porsild's dismissal (1930, p. 11) of '*Calamagrostis... hyperborea*' as unqualifiedly common, and his implication that the present species is relatively rare in our area. Roshevitz (in Komarov, Fl. U.R.S.S., II, pp. 215–17; 1934) separates *C. borealis* Laestad. (sub nom. *C. groenlandica* (Schräd.) Kunth) from *C. neglecta* on characters which, however, seem quite inadequate.

My material from Qag. in Tun. Fj. includes a single specimen (no. 11016a) which is somewhat proliferous, differing from the typical form in having the glumes narrower and longer (4–5.5 mm. instead of about 3.5 mm. long), and the lemmas also narrow and prolonged (up to 8 mm. long). Functional parts are usually absent and the awn frequently so. This form is not viviparous; it probably represents a more pathological state (perhaps resulting from a nematode attack as in the cases cited under *Agrostis canina*) and as such is not deserving of a name.

*CALAMAGROSTIS PURPURASCENS* R.Br. apud Richardson — Found again (cf. Porsild, 1930, p. 11) at Kiagtut (no. 11144), and in the following additional localities: Gl. Qagss. (nos. 10728a, 10743); Qag. in Tun. Fj. (no. 10985). My material, although in its awns (which scarcely exceed the spikelets) and some other minor characters not fully typical of this variable species, yet falls within its general form-series and, as was agreed by Dr Thorv. Sørensen, cannot well be referred to any other. The dry sandy habitat and frequent limitation to rigorously exposed ridges moreover agrees well with its occurrence in the Far North.

*DESCRAMPSIA ALPINA* (Linn.) Roem. & Schult. — Common. Near Igaliko I found, growing in a bed of the usual viviparous plants low down near the shore, a few non-viviparous specimens (no. 11279) with anthers, awns, and open panicles reminiscent of *D. caespitosa*. It is probably in deference to the existence of some such plants that Lange says (1880, p. 163): 'Naesten alle grønlandske Exempl. . . høre til Formen  $\beta$ ' (*vivipara*) and (1887, p. 296) 'Forma typica in Groenlandia rara'. However this may be, it seemed at first that these specimens of mine ought to be referred to the latter polymorphic and otherwise circumboreal species which, excluding the segregates *D. brevifolia* R.Br. (*Aira arctica* Spreng.) and *D. pumila* (Ledeb.) Ostenfeld, has surprisingly enough not yet been authoritatively reported from Greenland except as a relatively recent introduction at Ivigtut (see Rosenvinge, 1892, p. 730, and Porsild, 1932, p. 9; also cf. p. 404 below). But

reference to early literature has now made me doubt the validity of the present-day conception of *D. alpina* as necessarily viviparous (there does not appear to be in preservation any specimen that can be accepted as the 'type' of Linnaeus's original *Aira alpina*). As, moreover, the *Deschampsia caespitosa* complex as well as the significance and very nature of vivipary is only imperfectly understood, I prefer not to found a new record on my few rather doubtful specimens (which do not in any case conform at all well with any known Eurasian form of *D. caespitosa*) but to refer them all provisionally to *D. alpina*, suspecting that Flovik's characterization (in *Hereditas*, xxiv, p. 284; 1938) of this as 'typically viviparous and highly polymorphous' is probably due to the inclusion of other species. In support of this policy it may be noted that at Kiangtut I found intermediate specimens (no. 11148) bearing bulbils in some of the spikelets and short awns in some of these as well as in others which appeared to lack proliferations, although no anthers were visible.

*DESCHAMPSIA FLEXUOSA* (Linn.) Trin. — Common. The size of the spikelets may be so variable, even on the same panicle, that var. *montana* (Linn.) Greml. with long spikelets does not on this character seem maintainable, at least so far as southern Greenland is concerned (see also Devold & Scholander, 1933, p. 137). According to Messrs A. J. Wilmott and J. P. M. Brennan, in Britain this varietal name is applied to the 'coloured mountain form (with a tendency to larger spikelets) as opposed to the 'normal pale lowland form'. In SW. Greenland, however, a still paler (probably albino) form occurred as occasional isolated patches (cf. Devold & Scholander, 1933, p. 138) in heathy areas elsewhere subdominated by the usual coloured plants. Concerning this very pale form — '*Aira flexuosa* L. v. *montana* (L.) f. *pallida* n. form. *Pallida*: arista saepissime indusa' (sic ex Berlin, 1884, p. 77) — Rosenvinge, however, remarks (1892, p. 730) 'arista plerumque exserta, tum non nisi colore a var. *montana* diversa'. This is true of my material except that there appears to be no constant difference in the length of the awns in the two phases (in both, the well-developed spikelets are generally 5–5.5 mm. long and two-flowered). It accordingly seems better to treat them merely as minor variations, the exact nomenclature of which cannot be determined at present as the necessary types and literature are not available.

*VAHLODEA ATROPURPUREA* (Wahlenb.) Fries (*Deschampsia atropurpurea* (Wahlenb.) Scheele) — Evidently rare, or else extensively overlooked as in SE. Greenland (cf. Devold & Scholander, 1933, p. 137). Not found by the Persilds or by me, but collected by the 1937 Dano-Norwegian expedition at Julianehaab (cf. Grøntved, 1938, p. 254).

*TRisetum spicatum* (Linn.) Richt. (aggr., including some already described varieties, etc.) — Common. So extremely variable that it would seem to be a waste of time to separate the numerous forms occurring in SW. Greenland, at least without the background of the extensive breeding and cytological work which is desirable in such a complex to give an indication of the true value of the various 'characters'.

*POA PRATENSIS* Linn. (sensu lat., incl. *P. alpigena* (E. Fries) Lindm.) — Common. As elsewhere very variable and on morphological grounds apparently impossible to subdivide satisfactorily.

*POA ARCTICA* R.Br. (*P. rigens* of authors, not Hartm.) — Fairly frequent, although omitted by Persild (cf. 1930) and, as far as I can make out, not previously recorded from this section of Greenland except in a general way by early authors. The majority of my specimens, although often rather large and coarse, are quite typical in more important characters, as agreed by Dr Thorv. Sørensen. They come from: bet. Agd. & Ig. Fjords (nos. 10513, 10539); Gl. Qagss. (no. 10745); S. of Qag. in Tun. Fj. (no. 10926); Qag. in

Tun. Fj. (no. 10989); Kingua in Tun. Fj. (no. 11074); bet. Ig. & Jul. (no. 11332); Julianehaab (no. 11385). There also occur frequent specimens transitional to *Poa pratensis* sensu lat.—e.g. nos. 10194 and 10283a from Sydprøven, and nos. 10429 and 10442a from Lichtenau.

*POA NEMORALIS* Linn. — Not nearly so frequent as has been supposed. Thus most of the material so named from Greenland that I have seen belongs instead to an attenuated, *nemoralis*-like form ('var. *glauantha* Blytt') of the common and extremely variable *P. glauca* (see below). Such plants, as well as the typical *P. glauca*, I was able to find in suitable shady places almost everywhere that I looked. But still there occur in the extreme south-west of Greenland, and most notably in our area, occasional plants with narrow glumes and small spikelets that seem to be the true *P. nemoralis* (fide A. J. Wilmott and J. P. M. Brenan). I found such at Sydprøven (no. 10282), Gl. Qagss. (no. 10800), Igaliko (no. 11286), and Julianehaab (no. 11424), and noted similar plants also at Kiatgut, although this last report requires confirmation as specimens are lacking.

*POA FLEXUOSA* Sm. — Akul. (no. 10413, fide A. J. Wilmott). For a detailed account of the taxonomy and phytogeography of this segregate of *P. laxa* Haenke apud Jirasek et al., see Nannfeldt (in Symbol. Bot. Upsalienses, no. 5, 1935). In 1938 I found it again—this time near Reykjavik in Iceland. Mr C. E. Hubbard agrees that my Greenland specimens are inseparable from Scottish and Scandinavian ones in the Druce Herbarium, Oxford, labelled by Nannfeldt '*P. laxa* var. *scotica* Druce fide Nannfeldt = *P. cacuminum* Nannf.' Both of these names are mere synonyms for Smith's plant. Although comprising only a single collection, my Greenland specimens show a range of variation very similar to that of the Scottish and Scandinavian ones in such characters as the shape and size of panicle and spikelets. They were found on damp gravel at about 1000 m. (3281 ft.) on the west side of the massive Akuliaruserssuaq, growing with good typical *P. alpina* (no. 10413a). The Iceland material occupied very similar situations and habitats (cf. also Ostenfeld & Grøntved, 1934, p. 25). *P. flexuosa* has nothing to do with *P. Hartzi* Gandoger emend. Sørensen; nor does it now appear to me conspecific with my N. Quebec specimens belonging to this group (see Polunin, 1940, p. 67). According to Nannfeldt (op. cit., p. 60), all previous reports of *P. laxa* or its immediate relatives from Greenland ought probably to be referred to other groups, which makes the present find highly significant. In this connection it is worthy of note that, in a copy of his 'Flora of Disko Island and the Adjacent Coast of West Greenland' which he recently gave me, Dr M. P. Porsild had crossed out *P. laxa* Haenke on p. 41 and written alongside 'absent from Grl.' (i.e. Greenland).

*POA GLAUCA* M. Vahl (aggr., including some already described varieties, etc.) — Common. Extremely variable, as elsewhere; in most instances it seems to be a waste of time to try to separate the almost endless forms. The complex appears to run into *P. nemoralis*—e.g. through nos. 10396a and 10471. A peculiar specimen with short narrow leaves is no. 11134 from Kiatgut; I could find nothing quite like it in the herbaria of Copenhagen, Kew, the British Museum, or Oxford.

*POA ALPINA* Linn. — Not really common except in the mountains. The frequent dwarfed, lowland turf specimens, so characteristic of pastures near the sea, which, following Dr J. A. Nannfeldt, I at first thought might belong to this species, are, according to Messrs A. J. Wilmott and C. E. Hubbard, referable rather to *P. pratensis* sensu lat.

*POA ANNUA* Linn. — Seen only around present-day habitations, where it may be very abundant. Probably introduced in relatively recent times (cf. Porsild, 1932, p. 46). It varies greatly in size and luxuriance with local habitat conditions, and particularly according to the amount of nitrogenous material in the manured or otherwise disturbed areas which it chiefly inhabits. Additional localities: Sydprøven (no. 10294); ? Qagsimiut (no. 10024, possible hybrid with *P. alpina*).



*PHIPPSIA ALGIDA* (Soland.) R.Br. (*Catabrosa algida* (Soland.) Fries) — Apparently absent from the immediate Julianehaab district—surprisingly enough even in the mountains—but noted again at Ivigtut (cf. Porsild, 1930, p. 12).

*CATABROSA AQUATICA* (Linn.) P. de Beauv. — Qagsimiut (no. 10025), growing in heavily trampled and pastured turf in the village, low down near the sea. Like the other plants with which it was associated, it was very reduced in stature, the axes of expanded inflorescences being only 3–5 cm. long. Little known in Greenland and entirely new to this sector, it may just possibly have been introduced from the north in relatively recent times, although it is not normally recognized as hemerophilous and in its one station was seen only in completely closed communities. My specimens answer to Lange's description (1887, p. 298) of his var. *borealis*, which he defined as 'pumila (c. 2" longa), decumbens, panicula spicaeformi-contracta, spiculis 2- v. 1-floris'. Cf. *Flora Danica*, fasc. LI, tab. MMMII, 1883, although from my material it appears that the lower branches of the panicle may later open out much more than these figures suggest.

? *PUCCINELLIA ARCTICA* (Hook.) Fernald & Weatherby (aggr.) — This may be something of a 'rubbish heap' whose clearance, like that of *P. angustata* aggr. to the north and west, must await a more comprehensive monograph than is at present available. It includes specimens taken early in the season that look like small examples of *P. Borreri* (Bab.) Hitchc. ex Robinson or its var. *islandica* (Lange), both of which have been reported from the area (by Lange, 1880, p. 168, and 1887, p. 298; also Rosenvinge, 1892, p. 731), and others taken after flowering which are so reminiscent of *P. distans* (Jacq.) Parl. that Mr Wilmott has referred them to that widespread (and often too widely interpreted—cf. Porsild, 1920, p. 44, and Holm, 1922, p. 12 B) species. However, for the time being it seems safest to follow earlier authors (cf. Rosenvinge, 1892, p. 732) and refer them as above, although retaining a query pending full clarification and revision of all arctic and subarctic members of this tiresome genus. The present category covers the plant referred to by Porsild when he wrote (1930, p. 12) that 'a well sized, more or less erect *Puccinellia* species was quite common' along the shores of the district visited. Porsild referred it tentatively to *P. retroflexa* (Curt.) Holmb. subsp. *borealis* Holmb., but none of my material is quite like any of the plants I have seen which have been so determined by Holmberg. And while I cannot take the responsibility of saying which of the several available names should be used, it seems to me to fit in with *P. arctica*, which Porsild already says (1920, p. 45) is 'probably a southern type in West Greenland'—see also Holm (1922, p. 14 B).

*PUCCINELLIA PAUPERCULA* (Holm) Fernald & Weatherby (? *Glyceria Langeana* Berl. in Öfvers. af Kongl. Vetensk.-Akad. Förhandl. Årg. 41, no. 7, p. 79; 1884) — Found at Julianehaab (no. 10107), Sydprøven (no. 10293), Gl. Qagss. (no. 10821), and bet. Ig. & Jul. (no. 11361). Well known farther north in West Greenland but not previously recorded from the southernmost section. This is the *Glyceria tenella* of Ostenfeld's 'Flora Arctica' and of most American authors but not of Lange, whose description (in Kjellman & Lundström, 'Phanerogamen von Nowaja-Semlja, Waigatsch und Chabarowa', p. 153<sup>1</sup> in A. E. Nordenskjöld, Die Wiss. Ergebn. d. Vega-Exped. VIII; 1883) of his *Glyceria tenella*, collected off the Siberian coast, does not fit the type specimen (in the National Herbarium of Canada, Ottawa) of the American plant which Holm, presumably without forgetting his own Siberian experiences but nevertheless without referring to Lange's description, later described as *Glyceria paupercula* (cf. Polunin, 1940, p. 83). If Berlin's specific epithet cited above can be substantiated, it is probably the one that ought to be used for this controversial little plant. Meanwhile, it should be noted that Hitchcock (in Amer.

<sup>1</sup> Pp. 313–4 in the Swedish edition of 1882, 'Vega-Expeditionens Vetenskapliga Iakttagelser' I, Stockholm.

Journ. Bot. xxi, p. 129, 1934, and Man. Grasses United States, U.S. Dep. Agric., Misc. Publ. no. 200, p. 82, 1935) advocates the use of the combination *P. pumila* (Vasey) Hitchc., although Vasey's publication (in Bull. Torrey Bot. Club, xv, p. 48; 1888) of his original *Glyceria pumila* was so inadequate as to be characterized in Index Kewensis, Suppl. 1, p. 185, merely as 'nomen'—cf. also Fernald & Weatherly (in Rhodora, xxxvi, pp. 346–8; 1934).

**PUCCINELLIA MARITIMA** (Huds.) Parl. — Evidently rare, since it was 'searched for without success' by the Porsilds. I had the good fortune to stumble on it at the following localities, of which the first-named appears to be new: Kiagtut (no. 11129; bet. Ig. & Jul. (nos. 11360, 11365a). With the form-series of this species I am not at all well acquainted, but my material appears identical with specimens verified by Holmberg (who for 20 years studied the northern Puccinellias but never felt decided enough to write them up!) and has, moreover, been kindly checked by Dr M. P. Porsild.

**PUCCINELLIA PHRYGANODES** (Trin.) Scribn. & Merrill (*Glyceria vilfoidea* (And.) Th. Fr.) — Common. Since this species is to be found growing in some abundance on almost any stretch of shore throughout the area that is not too steep and rocky, it seems superfluous to continue listing separate localities. Said to be always sterile in SW. Greenland, but I found a single withered culm at Sydproven (no. 10301, British Museum set).

**FESTUCA BRACHYPHYLLA** Schultes (*F. ovina* Linn. var. *brevifolia* (R.Br.) Hart) — Fairly common, but in most places far from abundant. Collected at Sydproven, Akul., bet. Agd. & Ig. Fjords, Gl. Qagss., Kingua in Tun. Fj., Kiagtut, and Igaliko. It varies somewhat in the length of the anthers, which are generally much less than 1 mm. long and always far smaller than in *F. ovina*—which latter, except as a recent introduction (cf. p. 404), appears to be absent from Greenland in spite of innumerable previous reports. Thus I made a careful search for *F. ovina* in the Julianehaab district in 1937 and once thought that I had been rewarded when I discovered, S. of Qag. in Tun. Fj., a tall and coarse plant (no. 10915) with anthers 2–2.5 mm. long which reminded me of this relatively southern species and particularly of its var. *duriusculu* (Linn.) Koch. However, it transpired in the end to be no more than a phase of the very variable *F. rubra*.

**FESTUCA VIVIPARA** (Linn.) Sm. — Common. I do not feel at all happy about this present arrangement of my viviparous Festucae from SW. Greenland, where further observation is certainly desirable—the more so now that apomixis as well as amphi-apomixis is known to be rife in the group. Thus there seemed in the field to be at least two quite different plants, viz. (1) a densely caespitose, generally small but sometimes quite tall one growing chiefly in marshes though probably allied to *F. brachyphylla*,<sup>1</sup> and (2) a more constantly tall, heavy-headed and more or less (but not densely) caespitose one of generally drier habitats that looked nearer to *F. rubra* in habit but still had the narrow stem-leaves and 'split' basal leaf-sheath of *F. ovina* sensu lat.<sup>2</sup> It appeared glaucous, and sometimes grew in damp places with the first-mentioned form. Whether or not these two (or more) apparently different plants are referable to any of the numerous European 'formae apomicticae' or 'formae amphi-apomicticae' distinguished by Turesson (in Hereditas,

<sup>1</sup> Scholander, however, gives (in Skrifter om Svalbard og Ishavet, Oslo, no. 62, p. 74; 1934) the anther length of *F. vivipara* as 2–2.5 mm., which is more suggestive of *F. ovina* sensu str. This affinity is also suggested by Dr W. O. Howarth (in lit.), to whom I sent specimens from some of my gatherings (see p. 366).

<sup>2</sup> These features suggest that it cannot be the NE. American *F. prolifera* (Piper) Fernald, which is allied to *F. rubra* and which like that species has a broad stem-leaf (fide A. J. Wilmott). In my material the basal sheaths are not reddish, and all anthers visible in the occasionally non-viviparous spikelets are about 2.5 mm. long, in both of which characters it differs from *F. prolifera* as described by Fernald (1933, pp. 134–5).

VIII, XIII & XV, 1926, 1930 & 1931), I am unable to determine without access to authenticated specimens. Meanwhile, it may be noted that all my specimens of both categories have more or less hairy glumes and pales, being thus referable to var. *hirsuta* (Lange) Scholander. But since no anthers or other such character were present in the smaller plant to distinguish it markedly even from the constantly larger one I prefer to leave them under the same name for the time being, especially having regard to the general plasticity of the group—in which, moreover, the chromosome numbers are very variable (see Flovik in Hereditas, xxiv, pp. 296 et seq.; 1938). The small form is common almost everywhere, but the large one was encountered only at and around Julianhaab (nos. 11388, 11393, 11417). When I sent specimens of no. 11393 and also of two numbers from Igaliko of the 'smaller form' to the British *Festuca* specialist Dr W. O. Howarth, he reported that all three differed, remarking (in lit.) that 'your no. 11251 is nearest to *F. ovina* Linn. (*F. ovina*, *eu-ovina*, *vulgaris*) and may possibly be a proliferated form of var. *hispidula* (Hack.). No. 11243 puzzles me—note the poor development of sclerenchyma—but this occurs frequently in *F. ovina* in Britain. Your 11393 has a broader leaf and probably comes under the larger forms which Hackel classified under *F. duriuscula* but which I emended to *F. longifolia* Thuill. Beyond this I cannot go'.

*FESTUCA RUBRA* Linn. — Common. Extremely variable, most often approaching or attaining the form with 'spiculae dense villosae', viz. var. *arenaria* (Osb.) E. Fries. However, this is to be found 'saepe mixtim crescens' with the typical form, as already noted by Lange (1880, p. 180), while my no. 11096 from the ruins said to be of Eric the Red's house at Qag. in Tun. Fj. has the paleae often blunt and so approaches var. *mutica* Hartm. Other variants occur introduced at Sletten in Agdluitsq Fjord (nos. 10379, 10380).

*NARDUS STRICTA* Linn. — Additional locality: Qagd. (no. 10460), which is a slight northern extension to the previously known range in West Greenland.

*AGROPYRON VIOLACEUM* (Hornem.) Lange — Not infrequent around ruins, but as usual extremely variable. Indeed so plentiful about the heads of Igaliko and Tunugdliarfik Fjords (cf. Rosenvinge, 1892, p. 726) that it seems unnecessary to list precise localities thereabouts. Notable, however, is a peculiar narrow-leaved form (with the expanded, free lamina 1–2 mm. wide<sup>1</sup>) from Kiagtut (no. 11124); otherwise my material conforms tolerably well with the measurements given by Devold & Scholander (1933, p. 132) for specimens from SE. Greenland. Thus the leaves are generally 4–6 mm. wide although some examples exceed this, whereas others, while quite robust and not attaining the extreme phase mentioned above, fail to reach 4 mm. in width. Again, the 'spikes' are generally 6–9 cm. long, but sometimes reach 10 cm. or, on the other hand, fail to extend 3 cm. even in otherwise robust specimens. The glumes are all 7–11 mm. long and there is generally a short awn.

*ELYMUS ARENARIUS* Linn. var. *villosus* E. Mey. — Common.

*DANTHONIA SPICATA* (Linn.) P. de Beauv. ex Roem. & Schult. — Gl. Qagss. (no. 10798). New to Greenland—cf. Polunin, (1938, p. 90). This noteworthy addition to the flora was discovered about 3 km. inland of the principal ruins at Gl. Qagss. The specimens are characteristic and indeed unmistakable, although the species is such a variable one that I was pleased to have the support of the Kew grass specialist (Mr C. E. Hubbard) when making the determination. The grass was subdominant between clumps of low, scrubby

<sup>1</sup> The glumes remain unusually broad towards their tips in this gathering, being here as below often 2–2.5 mm. wide; nevertheless, they taper to an acute point and sometimes finish up with a short awn. I have been urged to describe this plant as a 'new' variety, but while it may perhaps be such I feel that already too many names have been proposed in this group without sufficient study of type specimens and consideration of full series. The same is true of *Poa glauca* and several other *typi polymorphi*, whose variation should be studied in the field and then described.

*Salix glauca* sensu lat. (with some *Betulae*) over a patch about 80 m. in extent of hillocky dry sandy soil, associated with *Campanula rotundifolia*, *Erigeron borealis*, *Viola ericetorum* var. *Friesiana*,<sup>1</sup> *Carex Bigelowii*, *Hieracium rigorosum*, *Alchemilla alpina*, *Agropyron violaceum*, *Deschampsia flexuosa*, *Poa glauca*, *Thymus*, etc. Although *Ranunculus acris* and *Rumex Acetosella* were present near by and the area appeared to have been disturbed by the Norsemen (cf. Polunin, 1937, p. 940), there were no signs of ruins in the immediate vicinity. Hitchcock (Man. Grasses United States, p. 303; 1935) gives the habitat and distribution as 'Dry and sterile or rocky soil, Newfoundland to British Columbia, south to Florida, eastern Texas, and eastern Kansas, in the mountains to New Mexico and Oregon'. Even if Marie-Victorin (Flore Laurentienne, p. 780; 1935) says 'Général dans le Québec' this should with little doubt refer only to the southernmost portion of that Province, whence numerous specimens are to be found in herbaria. I can find no evidence or even claim (other than this implied one of Victorin) that it reaches the subarctic belt in Canada, although other species of *Danthonia* do so. Indeed, Professor M. L. Fernald has recently confirmed (in lit.) that the northernmost known stations of *D. spicata* in eastern America are in Newfoundland and on or near the northern coast of the Gulf of St Lawrence.

### CYPERACEAE

*ERIOPHORUM SCHEUCHZERI* Hoppe — Common.

*ERIOPHORUM ANGUSTIFOLIUM* Honck. — Common. Varying markedly in robustness, as usual in northern (other than high-arctic) regions. Honckeny (Vollst. Verz. Deutsch. i, p. 153; 1782), whose rare work can be seen in the British Museum, Bloomsbury, clearly antedates Roth in the publication of this name—cf. also Becherer in Candollea, iv, p. 63; 1929: and Honckeny (Syn. Pl. Germ. i, p. 322; 1792) concerning differences between *E. angustifolium* and *E. polystachyon* Linn.

*SCIRPUS CAESPITOSUS* Linn. var. *callosus* Bigel. — Common.

*SCIRPUS PAUCIFLORUS* Lightfoot — Not infrequent in the 'inner fjord' region. The paucity in records of this species from Greenland—there were in 1937 only three sheets of it in the Arctic Herbarium at Copenhagen—may well be due merely to its small size, for actually I found it growing gregariously in almost every place around the heads of Igaliko and Tunugdliarfik Fjords where I examined suitable muddy habitats near the shore. Additional localities: S. of Qag. in Tun. Fj. (no. 10970); Kingua in Tun. Fj., plentiful.

*ELEOCHARIS PALUSTRIS* (Linn.) Roem. & Schult. — Additional locality: Kiagtut (nos. 11191, 11192, 11200). Vahl's (cf. Lange, 1880, p. 128) and Rosenvinge's earlier collections from Igaliko, the only station previously known in Greenland for a plant of this group, were at first named *E. palustris* but later revised by Harald Lindberg (in 1902) as *E. uniglumis* (sub nom. *Scirpus*), to which indeed they seem to be properly referable. However, my material from Kiagtut, which differs from the Igaliko specimens most noticeably in its much greater size (many of the culms exceed 50 cm. in height and 2 mm. in breadth when pressed), seems nearer to *E. palustris* (fide Johs. Grøntved and Thorv. Sørensen) except on the character of the bracts which, according to Conservator Wiinstedt who also was kind enough to inspect my material, although variable, suggest that it ought to be placed with *E. uniglumis* Link. In many other places as well, especially in the north, it seems difficult to keep the two apart—fide Dr H. K. Svenson (in lit., and cf. in Rhodora, xli, p. 56; 1939). Most of my specimens fall within the general form-series of *E. palustris* (fide A. J. Wilmott and J. P. M. Brenan), and accordingly are so referred.

<sup>1</sup> See p. 391.

*KOBRESIA MYOSUROIDES* (Vill.) Fiori & Paol., Fl. Ital. I, p. 125; 1896 (*K. Bellardi* (All.) Degland apud Loisel., *K. scirpina* Willd., *Elyna Bellardi* (All.) Hartm., *E. spicata* Schrad.) — Fairly common, and indeed often locally dominant in the more 'continental' fjordhead and inland regions. Not mentioned by Porsild, although I have seen plenty of specimens from Igaliko collected by Vahl (cf. Lange, 1880, p. 130) and Rosenvinge. Other localities include: bet. Agd. & Ig. Fjords (nos. 10517, 10518, 10548, 10572); Gl. Qagss. (cf. Rosenvinge, 1892, p. 717); S. of Qag. in Tun. Fj. (no. 10945); Qag. in Tun. Fj. (not collected); Kingua in Tun. Fj. (cf. Rosenvinge, 1892, p. 717); Kiagtut (not collected); bet. Ig. & Jul. (no. 11320).

*CAREX NARDINA* E. Fries — Not infrequent. Additional localities: Akul. (no. 10391); bet. Agd. & Ig. Fjords (no. 10550); Igaliko (not collected). As usual variable, most notably in the size and shape of the spikes and perigynia. These latter are especially long-beaked in my no. 11143 (from Kiagtut, where the species has been found before), which has, moreover, unusually large but narrow and pointed scales. In it the beaks stick out so prominently and the perigynia cause the scales to diverge so widely that until the fruits are lost the inflorescence has almost the appearance of that of *C. maritima*. I long worried about how to dispose of this form, but now agree with Mr E. Nelmes, to whom I sent specimens, that in most characters it falls within the limits of *C. Hepburnii* Boott—or, as I prefer to call it, *C. nardina* var. *Hepburnii* (Boott) Kükenthal. The especial prominence of the beak and the narrowness and tapering ends of the perigynium in no. 11143 are, however, at variance with the *Hepburnii* element as usually described, although authors disagree about the shape of the perigynium. The serrulations on the upper part of the perigynia are also unusually prominent, although not more so than in some of my specimens from the Canadian Eastern Arctic. Mr Nelmes (in lit.) writes that Kreczetowicz 'in his review of Mackenzie's monograph states that *C. nardina* Fries does not occur in America but is "native only to a very limited part of Scandinavian Lapland (see Gorodkov" in Trans. Mus. Bot. Acad. U.S.S.R., xx, pp. 199, 201; 1927)'. These publications are unfortunately not available; but from a survey of the limited Scandinavian material (seven collections, all from northern Norway) of *C. nardina* in the Fielding Herbarium at Oxford I am inclined to think that the rather extreme Russian statement may yet have some justification. Certainly *C. nardina* sensu lat. is a variable complex, whose rarity in inhabited regions, small size, and highly characteristic habit may account for perhaps unwarranted neglect on the part of the usually very watchful boreal caricologists. Any revision must take into account, and should redescribe in greater detail, var. *atriceps* Kükenthal, described from West Greenland as merely having 'Culmus strictus elatior. Pars ♂ spiculae prominens. Squamae ♀ profunde badiae.' Its author states that it 'steht zwischen der typischen Form und der nord-amerikanischen var. *Hepburnii*' (Kükenthal in Fedde, Repert. sp. nov. VIII, p. 7; 1910).

*CAREX CAPITATA* Linn. — Fairly common, and of such general distribution, including high altitudes, in the district traversed that it would seem superfluous to continue to cite individual localities. I collected it ten times and made notes of its occurrence on as many occasions again, including once above 1200 m. (3937 ft.) on Akul.

*CAREX GYNOCRATES* Wormskj. apud Drej. — Not infrequent; indeed of such general occurrence around the heads of the larger fjords that it seems only just worth while listing the following 'new' localities: bet. Agd. & Ig. Fjords (nos. 10591, 10605, 10628, 10633); S. of Qag. in Tun. Fj. (no. 10969); Kingua in Tun. Fj. (no. 11044). The species varies greatly in appearance with the number of fruits per axis, which may be anywhere from none up to fourteen.

From Igaliko I have material kindly sent by Eilif Dahl of *C. Langeana* Fernald, which, however, is sterile and appears to represent a mere hybrid of the present species with

*C. maritima*. This is the popular view and was, moreover, already suggested by Fernald (1933, p. 218) when he named after Lange the plant which the latter had misidentified as *C. duriuscula* C. A. Meyer. It is worthy of note that both of the supposed parents occur plentifully at Igaliko.

CAREX SCIRPOIDEA Michx. — Common.

CAREX MICROGLOCHIN Wahlenb. — Like many other small grass-like plants, the present species is much less rare than the comparatively few previous reports of it would suggest. Additional localities: bet. Agd. & Ig. Fjords (no. 10557); Kingua in Tun. Fj. (no. 11047); Kiagtut (no. 11146). My specimens vary in height from 5 to 25 cm.

CAREX MARITIMA Gunn. (*C. incurva* Lightfoot) — Said by Porsild (1930, p. 12) to be rare in this sector, but this is a statement with which I cannot agree, having seen it growing in plenty at Gl. Qagss. and Igaliko (in both of which stations it has been found before) and also at the additional localities of Kingua in Tun. Fj. (no. 11045) and Kiagtut (no. 11108) —indeed almost everywhere around the heads of Igaliko and Tunugdliarfik Fjords that suitable sandy shores present themselves, and sometimes even a considerable way inland. As elsewhere the species varies in size and form with local habitat conditions. Concerning the supposed hybrid with *C. gynocrates*, see under that species (p. 368).

CAREX MACLOVIANA d'Urv. (*C. festina* Dewey) — Like many other species of this great genus the present one is common in our area, in spite of Lange's contention to the contrary (1880, p. 135). Even if one follows, as I still attempt to do, the *recommendation* about capitalization in the 'International Rules', it seems clear from the recent observations of Fernald (in *Rhodora*, XLIV, pp. 71-2: 1942) that in the above specific epithet one should 'follow the original author, D'Urville, in using a lower-case initial'.

CAREX PRATICOLA Rydb. (*C. pratensis* Drej. 1841, not Hose 1797) — Not infrequent on ruins and in surrounding dry pastures. Additional localities: S. of Qag. in Tun. Fj. (no. 10958); Qag. in Tun. Fj. (nos. 11008, 11019); Kiagtut (no. 11168).

CAREX BIPARTITA All. (*C. lagopina* Wahlenb., *C. Lachenauii* Schk.) — Generally common, but apparently wanting in some places. The name used above, adopted by most recent American authors, is at least the earliest that can be applied to this controversial plant (cf. Mackenzie, N. Amer. Fl. XVIII, p. 88: 1931).

The halophytic var. *glareosa* (Wahlenb.) Polunin (*C. glareosa* Wahlenb.) was also collected. That most of the Greenland material which has passed as this plant belongs instead to a separate form has recently been pointed out by Erlandsson (in *Bot. Notiser för år 1937*, p. 212: 1937), who follows Mackenzie (in N. Amer. Fl. XVIII, p. 90: 1931) in maintaining it as a distinct species, *C. marina* Dewey. This, however, appears to be a mere further variety (var. *amphigena* (Fernald) Polunin) of *C. bipartita*, showing, according to my field observations in various arctic and subarctic lands, rather frequent transitions to var. *glareosa*. Such transitions (Erlandsson's *C. glareosa* × *marina*) also occur in SW. Greenland—e.g. my no. 11076 which was found growing with typical var. *glareosa* (no. 11075) at the head of Tun. Fj. Other 'good' specimens of the true var. *glareosa* from southern Greenland are 'A. E. and M. P. Porsild, Igdlorsuit, Prins Christian's Sund, July 21, 1925' and Jens Vahl's 'in locis glareosis ad littus sinus Tassermit 1829 Aug.' *pro parte*, both in the Arctic Herbarium at Copenhagen.

However, most of the plants in SW. Greenland, like the vast majority of those from elsewhere in Greenland and from North America (cf. Fernald in *Rhodora*, VIII, p. 46: 1906), belong instead to var. *amphigena*, which is very common in our area, whereas var. *glareosa* is not.

*CAREX MACKENZIEI* Krecz. (*C. norvegica* Willd. ex Schk. 1801, not Retz. 1779 & 1795) — Gl. Qagss. (no. 10741); Igaliko (no. 11254). New to Greenland (cf. Polunin, 1938, p. 90), but found again later in the year near Ivigtut by the 1937 Dano-Norwegian Botanical Expedition (who also discovered it independently at Igaliko, cf. Grøntved, 1938, p. 253). According to a written label in my possession, Eilif Dahl found the species in Arsuk Fjord (see under *C. canescens*); but it is not clear whether this was reported by Grøntved (in loc. cit.). In all the three confirmed localities the plant was growing in considerable abundance—although only very locally in its usual saltmarsh habitat—and it is indeed remarkable that none of the ‘long line of well-trained experts...and...still larger number of skilful amateurs’ (cf. Porsild, 1930, p. 5) who have carried out botanical investigations in the region has ever noticed it. It is a characteristic and indeed unmistakable species occurring also in Iceland and on the west coast of Hudson Bay; the Greenland specimens are indistinguishable from material which I have collected in these and other places.

*CAREX CANESCENS* Linn. — Common. Frequently smutted, and sometimes showing transitions, probably the result of hybridization, to *C. brunnescens*—e.g. no. 11437 from Julianehaab.

Eilif Dahl has sent me two specimens which he collected during the Dano-Norwegian Expedition and labelled, with little doubt correctly, ‘*Carex helvola* Blytt...Eqaluit, Igaliko Fjord, 9.8.1937’ and ‘*Carex pseudohelvola* Kihlman...Eastern side of the mountain Kūgnait, Arsukfjord, 11.9.1937’. Also in my collections are specimens closely matching both of these (e.g. the two parts of no. 10446 from Lichtenau). The former represents the hybrid *C. canescens* × *bipartita* (cf. Kükenthal in Engl. Pflanzenreich, iv, 20—Cyperaceae-Caricoideae, p. 220, 1909, and Mackenzie, N. Amer. Fl. xviii, p. 97, 1931) and has already been reported from a number of localities in southern Greenland (by Lange, 1887, p. 288; Rosenvinge, 1892, p. 719; Devold & Scholander, 1933, pp. 115–16); both Dahl’s and my specimens cited above lack properly developed fruits, but are sometimes smutted. The latter is said to be *C. canescens* × *Mackenziei* (cf. Kükenthal, op. cit., p. 221, and Mackenzie, loc. cit.), and it is significant that on its label Dahl noted ‘with *Carex norvegica*’.

*CAREX BRUNNESCENS* (Pers.) Poir. (*C. vitilis* Fries) — Common.

*CAREX BICOLOR* All. — Evidently rare in this sector of Greenland since it escaped the notice of the Porsilds, while I found it only at Gl. Qagss. (nos. 10794, 10814), where it has been collected before (cf. Lange, 1880, p. 138). For a recent account of the distribution, etc., of this very interesting little plant see Polunin in Journ. Bot. LXXIX, pp. 158–60; 1941.

*CAREX RUFINA* Drej. — Said by Grøntved of the Dano-Norwegian Botanical Expedition of 1937 to be not infrequent in the Julianehaab district. I am afraid that, like the Porsilds in 1925, I missed it—except for one doubtful specimen collected at Julianehaab (no. 11432).

*CAREX BIGELOWII* Torr. ex Schwein. (*C. rigida* Good. 1794, not Schrank 1789; *C. concolor* of authors, not R.Br.; *C. hyperborea* Drej. and including other spp. reported e.g. by Lange, 1880, pp. 142 et seq.) — Common, but extremely variable as in other parts of Greenland, whence there have been proposed several segregate species and varieties which, however, when sufficient material is examined appear to be of little or no value owing to instability of the alleged differentiae. Some of these segregates have been reported from our area, e.g. by Lange (loc. cit.) and Rosenvinge (1892, pp. 722–3). Indeed, the species exhibits such plasticity in the region traversed that I made no less than thirty-three collections of it, but still without being able to separate any obviously significant entity. One has

merely to conclude that the more peculiar specimens and deviating tendencies one gathers, the more numerous and continuous and extreme become the 'lines' of variation which it is possible to exhibit from the resulting material. However, I must mention some specimens through which this species seems to 'run into' *C. Goodenowii* and *C. salina*, and others (e.g. no. 10574 from bet. Agd. & Ig. Fjords and no. 10862 from Igaliko) which almost match the description and figure in 'Flora Danica' of *Carex stans* Drej. The plant now generally styled *C. aquatilis* var. *stans* (Drej.) Boott does not quite conform to this description and figure, being to my mind nearer to true *C. aquatilis* Wahlenb., which also seems to be absent from the extreme south-west of Greenland. With regard to the name used above, it should be emphasized that Robert Brown's type specimen of his *C. concolor* belongs to the series usually called *C. aquatilis* var. *stans*, and so cannot be applied to the present species (cf. Polunin, 1940, p. 130).

**CAREX GOODENOWII** J. Gay — This, like the last species, is common but extremely variable; the numerous forms occurring in SW. Greenland seemed to require further study not merely in the herbarium but also in the field. I myself made thirty-two gatherings, several of which at first sight appeared to represent different species. In the field I also had the impression that plants belonging to this *C. Goodenowii* form-series were hybridizing with *C. Bigelowii*, with *C. stylosa*, and possibly also with phases of the tiresomely polymorphic *C. salina*. Hybrids of *C. Goodenowii* with '*C. rigida*' and *C. salina* have been reported from Northern Europe—(cf. Kükenthal in Engl. Pflanzenreich, iv, 20—Cyperaceae-Caricoideae, pp. 371 and 381; 1909). However, Mr Wilmott informs me that my specimens collected to illustrate such possible hybridization almost all fall within the limits of the extremely plastic *C. Goodenowii*, and could quite likely be matched with British specimens of this. Very recently Fernald (in Rhodora, XLIV, pp. 300–2; 1942) has advocated the use of the name *C. nigra* (Linn.) Reichard for the present species which has also passed as '*Carex acuta* Linn.'

**CAREX SALINA** Wahlenb. (aggr., incl. *C. reducta* Drej. and probably some of the other species reported by Lange, 1880, pp. 141 et seq.) — Very variable, running into phases of *C. Bigelowii* and *C. Goodenowii* and showing all stages of transition from broad-leaved, robust plants  $\frac{1}{2}$  m. or more high to the very reduced var. *subspathacea* (Wormskj.) Tuckerm. This last is by many retained as a separate species (*C. subspathacea* Wormskj.), but for reasons already stated (Polunin, 1940, pp. 133–4) I am very doubtful whether it can stand as such. Additional localities for *C. salina*: Lichtenau (no. 10434); bet. Agd. & Ig. Fjords (no. 10640); S. of Qag. in Tun. Fj. (no. 10960)—and for var. *subspathacea*: Sydprøven (no. 10245); Qagdl. (no. 10481 a); Gl. Qagss. (nos. 10750, 10759); Qag. in Tun. Fj. (not collected); Qanger. (not collected); ? Julianehaab—the specimen good but the locality doubtful owing to the original label being lost.

I have nothing at all constructive to add to the controversy (see Fernald in Rhodora, XLIV, pp. 293–4; 1942) as to whether *C. paleacea* Wahlenb. (*C. maritima* O. F. Muller<sup>1</sup> 1777, not Gunn. 1772) occurs in Greenland; but in view of the many recent finds (or substantiation of old claims) of widespread boreal plants in southern Greenland it would seem unwise to deny the distinct possibility of its occurrence there.

[**CAREX LYNGBYEI** Hornem. — Not seen—cf. Porsild (1930, p. 13).]

**CAREX HALLERI** Gunn. (*C. VahlII* Schk., *C. alpina* 'Swartz ex' Liljebl.) — Common. Variable chiefly in height, specimens up to 50 cm. occurring at Kiagtut. I have the impression that this species may occasionally hybridize with *C. atrata* (q.v.) in SW. Greenland as in some parts of Europe (cf. Kükenthal, op. cit., p. 401), but unfortunately my one gathering of the apparent hybrid (*C. Candrian?* Kneucker) has been mislaid. It came from

<sup>1</sup> The original spelling in Flora Danica, fasc. XII, p. 8.



the vicinity of a waterfall near Julianehaab. According to Fernald (1933, pp. 220 & 398, and in *Rhodora*, XLIV, p. 304, 1942) the name for the present species should be changed again—this time to *C. norvegica* Retzius.

*CAREX BUXBAUMII* Wahlenb. (*C. polygama* Schkuhr 1801, not J. F. Gmel. 1791; *C. fusca* of authors, prob. not All. —see Mackenzie, N. Amer. Fl. xviii, p. 374; 1935) — Collected again by the Dano-Norwegian Expedition in Sermilik Fjord (cf. Grøntved, 1938, p. 253). A duplicate specimen from here, sent to me by Eilif Dahl, compared well in all visible points with material from Loch Dubh, Arisaig, East Inverness (N. D. Simpson, no. 36:956), kindly supplied by Mr J. P. M. Brennan and distributed as *C. fusca* All.

*CAREX STYLOSA* C. A. Mey. (incl. *C. nigrifolia* Drej., which according to Fernald in *Rhodora*, XLIV, pp. 302-3, 1942, represents a distinct variety) — Common in certain places, especially around Julianehaab, but, I think, absent from some considerable areas around the heads of the fjords. My material shows considerable variation in the length and shape of perigynia and scales, as well as in some of the other characters mentioned by Fernald (loc. cit.); unfortunately I have no 'western' material for comparison. Eilif Dahl has sent me an interesting specimen labelled '*Carex stylosa* × *rariflora*' from 'Upernivik north-east of Sarsdlok'.

*CAREX ATRATA* Linn. — Quite common, although Lange said (1880, p. 139) 'sjelden'.

*CAREX DEFLEXA* Hornem. — Fairly frequent, after all. Additional localities: Julianehaab (nos. 10168, 11430); Sydprøven (nos. 10268, 10268a, 10309a); Akul. (no. 10392); Qagdl. (no. 10489 atypical small tufts—normal-looking plants were seen but not collected); bet. Agd. & Ig. Fjords (not collected); bet. Ig. & Jul. (no. 11342). Varies much in height and laxity with local habitat conditions.

*CAREX SUPINA* Wahlenb. — Locally plentiful at Gl. Qagss., Igaliiko settlement, and Kiatut, in all of which places it has been found before (cf. Porsild, 1930, p. 13). No new localities.

*CAREX RARIFLORA* (Wahlenb.) Sm. — Common almost everywhere but rather variable, some of the plants being so large, with broad, light brown spikelets, and altogether so reminiscent of *C. limosa* Linn., that I collected them carefully in the hope that they might prove to belong to that species, which, however, seems to be absent from Greenland. Nor do any of my specimens appear to be referable to the already doubtful subsp. *stygia* (Fr.) N. J. Andersson, although Hultén (Fl. Aleutian Is. and Westernmost Alaska, p. 118; 1937) states that this 'can be said to be intermediate between' *C. rariflora* and *C. limosa*.

One of the minor variations, even if it grows with and sometimes shows transitions to the typical form, is in its full development so striking as to deserve a name—f. *erecta* nov. forma. *Rami* florescentes robustiores et latiores (vix 1 cm. long.) quam in forma typica, semper erecti vel suberecti. *Spicula masculina* saepe absens vel imperfecta. Typus in Herb. Mus. Brit.: Nicholas Polunin, South of Qagssiarssuk in Tunugdliarfik Fjord, no. 10923a, 14 August 1937. No. 10505 from bet. Agd. & Ig. Fjords and no. 10782 from Gl. Qagss. are intermediate between f. *erecta* and the typical form.

There is an English rendering of the above definition in my 'Botany of the Canadian Eastern Arctic', I, p. 127, 1940, whose publication was to have been preceded by that of the present Latin diagnosis in *Meddelelser om Grønland*—for which, however, war prevented delivery of the MS.

*CAREX MAGELLANICA* Lam. (sensu lat.) — Bet. Agd. & Ig. Fjords (no. 10504), and S. of Qag. in Tun. Fj. (no. 10920); also Gl. Qagss. according to my field notes, but this needs confirmation. Not previously recorded from Greenland, and not represented in the

Arctic Herbarium at Copenhagen except from Iceland (leg. Jónsson, Davíðsson, Óskarsson) and Fennoscandia, but Dr J. Iversen informs me that he has found it in the Godthaab district in much the same habitat—i.e. growing with *C. rariflora* in *Sphagnum* or other wet moss areas by the sides of freshwater lakes and tarns.

**CAREX GLACIALIS** Mackenzie (*C. pedata* Wahlenb. 1812, not Linn. 1763) — Rarely found before in SW. Greenland and omitted by Porsild (cf. 1930), but collected twice in the hills at Igaliko (nos. 11301, 11305), whence it was early reported by Lange (1880, p. 151). It may perhaps be not infrequent at this place, as I also saw two scraps mixed in with other Cyperaceae in the collections which Eilif Dahl made there the same summer. As usual it grew on dry calcareous soils, especially in 'barren' gravelly areas, Dahl's specimens being from such situations but 'near the sea'. According to Fernald (in *Rhodora*, XLIV, p. 292; 1942), 'The plant of Greenland... seems to be very characteristic *C. glacialis*'.

**CAREX PANCEA** Linn. — Although not found by the Porsilds or other recent visitors to the district, this species proved to be far from rare in several places along my route (it was collected copiously on ten occasions), being indeed of almost general occurrence around the heads of Igaliko and Tunugdliarfik Fjords. The following new localities may be noted: bet. Agd. & Ig. Fjords (no. 10598); Gl. Qagss., frequent; S. of Qag. in Tun. Fj. (no. 10963); Kingua in Tun. Fj. (no. 11062); bet. Ig. & Jul. (no. 11352).

**CAREX CAPILLARIS** Linn. — Common. Very variable in size, some of the specimens exceeding 30 or even 40 cm. in height and being referable to *f. major* (Drej.) Kükenthal, which may perhaps after all be more than a shade or shelter phase (see 'Flora Danica', fasc. XL, p. 9, and tab. MMCCCLXXIV; 1843). Examples of *f. major* are no. 11416 from Julianehaab and no. 11292 from Igaliko. It may be noted that I have written Kükenthal's name in the above citation in the manner in which he himself wrote it, for, the author's name 'not being part of the scientific name, is not necessarily Latin in form' (J. E. Dandy, in. lit.).

There occurs also var. **Porsildiana**, nov. var. *Rami florescentes erecti perenniores quam in forma typica. Spiculae femineae frequentiores plerumque crebriusque conglobatos flores ferentes. Spiculae masculinae fere semper perigynia nonnulla quoque ferentes, perigyniis minoribus quam in forma typica, 1.3–1.8 mm. longis, rostro brevior (0.3–0.5 mm. longo). Typus in Herbario Musaei Britannici, co-typus in Herbario Fielding Universitatis Oxoniensis: Nicholas Polunin, Gammel Qagssiarssuk, Igaliko Fjord, no. 10789, 7 August 1937. This variety was defined in English in my 'Botany of the Canadian Eastern Arctic', 1, p. 123, 1940, whose publication was to have been preceded by that of the present Latin diagnosis in *Meddelelser om Grønland*—for which, however, war prevented delivery of the MS.*

In the Arctic Herbarium at Copenhagen I have seen other specimens of var. *Porsildiana*, whose distribution evidently includes North America and Iceland as well as SW. Greenland. In Iceland it can hardly be common or widespread, as I failed to find it during lengthy treks in the west and northwest in 1938. Indeed, the only specimen that I have ever seen in Iceland was in the Museum at Reykjavik—coll. Ingólfur Davíðsson, 28 July 1933 at Finnastaðaréyrar, Eyjafjörður. Typical specimens of var. *Porsildiana* are: (i) an early collection (mixed with the typical form) by Jens Vahl from the type locality: 'in locis humidis Kaksarsuk sinus Igaliko 1828 Aug', (ii) 'St. Stefansson 1895—25/7 Dis i Moðrudal, Island' (already noted as 'forma') and 'Th. Sørensen, Skagafjord ved Svartá, Maclifell, Island 18/7 1930' already noted as 'var.', (iii) 'J. M. Macoun, Rankin Inlet, no. 79007, 1910', and (iv) 'M. O. Malte, Southampton Island, no. 120593, 1928'. This last was collected at the Hudson's Bay Company's post at Coral Harbour in South Bay, though this is not stated on the label. All these four specimens are in the Copenhagen Herbarium, but I have notes to the effect that I have seen 'duplicates' of Macoun's no. 79007 in the New York Botanical Gardens, Gray (Harvard University), and Ottawa (National Museum of Canada) Herbaria. However, this does not necessarily mean that

all the individuals of this number belong to var. *Porsildiana*, as most of them were seen only before its detection; the same applies to those specimens of Malte's no. 120593 that are housed in America. This impurity of gatherings containing var. *Porsildiana* suggests that it frequently grows mixed with the typical form; nevertheless, it seems to be more definitely confined to calcareous habitats than the latter, and to prefer less wet or at least better drained areas especially of light sandy soil. Were it not for the fact that in some places it appears to 'run into' true *Carex capillaris* (and this most notably in East Greenland which lies near the centre of its known distribution), I would have proposed it as a separate (micro-) species, for it has some other minor 'characters' even beyond the several mentioned in the diagnosis. It is altogether a charming little plant even compared with the attractive typical form, and it is a great pleasure to name it after that foremost student of the Greenland flora, Morten P. Porsild, who with his sons discovered so many interesting plants in the Julianehaab district in 1925, and who would probably have found this one as well if there had been more opportunity for excursions inland.

*CAREX VIRIDULA* Michx. (*C. Oederi* of authors, not Retz.) — Found again at Igaliko, where plentiful material was collected (nos. 10897, 10901, 11202). When working in the Copenhagen Herbarium in 1937 I made a note to the effect that my own and other material from Igaliko Fjord (outside of which no member of this group has been found in Greenland), while it appeared to be somewhat intermediate, was 'not directly referable to the European *C. Oederi* but to this smaller-fruited, predominantly American segregate variety or species' (*C. viridula*—cf. Wiinstedt in Bot. Tidskr., København, XLIII, p. 505; 1936). However, Mr A. J. Wilmott, after comparing my specimens with material in the British Museum, stated that the Greenland plants appeared to be identical with British material of '*C. Oederi*'. Accordingly we together made a further examination of the problem, the results of which are set out in the next paragraph.

Since Nelmes (in Journ. Bot. LXXVII, pp. 301 et seq.; 1939) has shown that the type of *C. Oederi* Retz. was a specimen of *C. pilulifera* Linn., the naming of these Greenland specimens depends on whether the European '*C. Oederi*' and American *C. viridula* Michx. are specifically distinct. Nelmes, following Mackenzie (N. Amer. Fl. XVIII, pp. 299 et seq.; 1935), is 'inclined to agree... that *C. viridula* Michx. stands specifically outside the orbit of the European species, even when this is understood in the broad sense of Kükenthal and of Mackenzie himself'. Our examination of British, Greenland, and continental North American material at Oxford leads us to a contrary opinion. We can see no difference whatever, either between the Greenland and British material, or between any of these specimens and American ones labelled '*Plantae Exsiccatae Grayanae* 168. *Carex Oederi* Retz., var. *pumila* (Cosson & Germain) Fernald... Syn. *C. viridula* Michx.' All have perigynia showing the same range in size, with short beaks (about one-third the length of the body), apparently identical wide-spreading lower bracts, and similar habit. On the basis of Mackenzie's key this would identify the British material with *C. viridula* Michx. as opposed to the European '*C. Oederi*', and Mackenzie himself (op cit., p. 304) refers the Greenland plant to *C. viridula*. All the characters used by Kükenthal to distinguish his American var. *viridula* from his essentially European '*C. Oederi*' are found in the British material we have examined. It is true that in '*Plantae Exsiccatae Grayanae* 167. *Carex Oederi* Retz.' the beak of the fruit is rather longer (perhaps half the length of the body of the fruit), as given by Mackenzie in his key for *C. Oederi*, but this no. 167 has long, slender bracts with 'the blade normally erect', which in the same key characterizes *C. viridula* as opposed to '*C. Oederi*'! If, therefore, Michaux's name *C. viridula* is correctly applied by Mackenzie, we consider that it is to be applied, without any varietal distinction, not only to the Greenland plant but also to the British and other European material, and that the question of applying the name *C. serotina* Mérat (see Nelmes, loc. cit., p. 304) to the European material does not arise—see also Bot. Soc. & Exch. Club Brit. Isles, Rep. for 1939-40, p. 261; 1942.

In European herbaria, small forms of *C. flava* Linn. aggr. ('var. *minor* Townsend') are commonly confused with '*C. Oederi*', and it may be that the presence of such specimens mixed with '*C. Oederi*' in Copenhagen were responsible for my first opinion that the Greenland plant was 'somewhat intermediate'; but unfortunately it is impossible just now to settle such questions.

**CAREX ROSTRATA** Stokes apud With. (*C. ampullacea* Good.; *C. inflata* of authors, *teste* Nelmes MS.) — Additional localities: bet. Agd. & Ig. Fjords (nos. 10502, 10521, 10600, 10616); S. of and around Qag. in Tun. Fj. (common and very luxuriant); bet. Ig. & Jul. (not collected). Having found this plant almost all the way from near the height of land bet. Agd. & Ig. Fjords (according to the nearest natives no one had followed this route before, at least in living memory in summer) to Qag. in Tun. Fj., often forming magnificent beds well away from any known ruins and ascending to an altitude of over 1200 ft., I feel that the main argument (see Ostenfeld, 1926, pp. 17-18, and Porsild, 1932, pp. 50-1) for assuming it to have been introduced to Greenland by the Norsemen is invalidated. To be sure it *may* have been so introduced; but the restriction of its area to within the once colonized regions may equally well indicate merely that it can only persist under the most favourable combination of conditions to be found in Greenland. Until it has been demonstrated experimentally that it is incapable of spreading to other regions, it seems equally permissible to postulate that it 'selected' these areas much as Nordic man himself once did.

*Carex rostrata* × *saxatilis* was also collected. Where *C. rostrata* and *C. saxatilis* are both common, not infrequent sterile intermediates are to be found (e.g. nos. 10575 and 10577 from bet. Agd. & Ig. Fjords, no. 10939 from S. of Qag. in Tun. Fj., and nos. 11351 and 11364a from bet. Ig. & Jul.) which it seems safe (*fide* Sørensen) to identify as hybrids between the two species. This intermediate is *Carex hymenocarpa* Drej., as Dr Thorv. Sørensen and I were able to confirm from Vahl's original specimens taken at Igaliko (cf. also Drejer's original description—*Revis. crit. Caricum bor. in terris Danic.*, p. 58; 1841—and *Flora Danica*, fasc. XLVIII, p. 12 and tab. MMDCCCLIX; 1871).

**CAREX SAXATILIS** Linn. (*C. pulla* Good.; *C. rotundata* of authors, not Wahlenb.)—aggr. incl. *C. vesicaria* Linn. var. *alpigena* Fries, cf. Rosenvinge (1892, p. 725)—Common almost everywhere. In this difficult group I follow that careful observer Dr Thorv. Sørensen, according to whose verbal information (cf. also Seidenfaden & Sørensen, 1937, p. 83) there is no true *C. rotundata* in Greenland (or, perhaps, anywhere in eastern North America), the plants from these regions which have passed under this name belonging generally to *C. saxatilis* Linn. This in the Julianehaab district is extremely variable; but if a sufficiently great material is examined the characters are seen to be so little constant that I am disinclined to take up any of the numerous sub- or microspecific entities that have been described. One thing has, however, always appeared to me certain, especially when working in the field in Arctic America—viz. that *Carex membranacea* Hook. (*C. membranopacta* L. H. Bailey, *C. compacta* R.Br.) is a very good species. I have seen no specimens of it from Greenland, but only examples of other species wrongly so determined, which may account for the confusion e.g. in Gelting (1934, p. 174).

## JUNCACEAE

**JUNCUS FILIFORMIS** Linn. — Rather frequent. Varying greatly in the length and prominence of the spathe and subtending bract, even in closely contiguous plants. New or supposedly new localities: Qagd. (no. 10468); S. of Qag. in Tun. Fj. (no. 10938); Qag. in Tun. Fj. (no. 10986); bet. Ig. & Jul. (not collected). Lange (1880, p. 124) already reported it from Tunugdliarfik Fjord without, however, giving any more precise locality.

*JUNCUS ARCTICUS* Willd. — Additional localities: bet. Agd. & Ig. Fjords (nos. 10585, 10627); Qag. and Kingua in Tun. Fj. (not collected, but already reported from this fjord by Lange, 1880, p. 124). Transitional to the next species is no. 10785 from Gl. Qagss.; from this locality *J. arcticus* has already been reported by Porsild (1930, p. 13), and I found it there again.

*JUNCUS BALTICUS* Dethard. apud Willd. — In Ostenfeld's 'Flora Arctica' (1902, p. 23), Gelert recorded *J. balticus* var. *europaeus* from SW. Greenland as 'very rare'. While the material so determined by Gelert was subsequently revised by Ostenfeld (in 1925) as *J. arcticus* × *filiformis*, and does indeed show some characters of the latter species, I have new specimens from the most favourable situations around the heads of Igaliko and Tunugdliarfik Fjords which, although they are usually sterile, cannot possibly be referred to this presumed hybrid. They are inseparable from authenticated specimens from Iceland of the circumboreal and very variable *J. balticus* and, as agreed by Dr M. P. Porsild and Mag. Johs. Grøntved, belong to this species in all key characters; Mr H. W. Pugsley and my colleague Dr A. R. Clapham consider them indubitable *J. balticus*. Such specimens I have found at the following localities: bet. Agd. & Ig. Fjords (no. 10599); Gl. Qagss. (no. 10784); S. of Qag. in Tun. Fj. (nos. 10957, 10966); Qag. in Tun. Fj. (no. 10981). Most of these specimens are to my mind still rather reminiscent of *J. arcticus* in some characters, and it would seem that Iceland and SW. Greenland lie in the ecotone of the two species, where they are not fully distinct although over most of the rest of their great range they are abundantly so.

*JUNCUS ALPINUS* Vill. var. *rariflorus* (Hartm.) Hartm. — Not rare. In using the above name for the Greenland representative of this group I am accepting the good advice of my colleague Dr A. R. Clapham and following Lindquist (in Bot. Soc. & Exch. Club of the British Isles, Rep. for 1931, pp. 780–1; 1932) who already records it as '*Planta borealis circumpolaris*'—see also Kreczetowicz & Gontscharov in Komarov, Fl. U.R.S.S. III, p. 538; 1935. According to Lindquist (in tom. cit., pp. 771 et seq.) *rariflorus* is synonymous with *J. nodulosus* Wahlenb., a name which Conservator K. Wiinstedt (cf. Bot. Tidsskr., København, XLIV, p. 72; 1937) had advised me to apply to my Greenland material, which, although it is somewhat variable, appears all to belong to the same series. My specimens have the capsules intermediate in shape between those of typical *J. alpinus* and *J. nodulosus* (sensu Pugsley in Journ. Bot. LXIX, p. 279, fig. B; 1931), but according to Lindquist (in tom. cit., p. 774) 'With reference to this character all transitions between the long-fruited *J. nodulosus* and *J. Marshallii* occur... This would indicate that Pugsley's new species [*J. Marshallii*] is very probably more closely related to *J. nodulosus* than it was at first supposed to be'. There indeed seems little doubt that *J. Marshallii* and *J. nodulosus* are conspecific; they may even be convarietal, as *J. alpinus* var. *rariflorus* and *J. nodulosus* seem to be (see above). In this connection it is worthy of note that Mr Pugsley himself appears to have difficulty in separating *J. Marshallii*, for during a visit to Oxford in 1942 he kindly inspected my material and wrote on some of my Greenland sheets 'cf. *J. Marshallii* Pugsl. and *J. alpinus* var. *rariflorus* Hartm.';<sup>1</sup> others, he noted, came 'very close to' his *J. Marshallii* or were even 'cf. *J. Marshallii*'. However, as has already been stated, the gatherings appear all to belong to the same general series; they came from: bet. Agd. & Ig. Fjords (nos. 10624, 10632); Gl. Qagss. (nos. 10730, 10792, 10808); Igaliko (nos. 10875, 11307). At the last-named place it was found long ago, and for the first time anywhere in Greenland, by Jens Vahl (cf. Lange, 1880, p. 124); at Gl. Qagss. it was later collected by Rosenvinge (cf. 1892, p. 714). Both

<sup>1</sup> This same note Mr Pugsley wrote on one of my sheets (no. 1854) collected in 1936 at Churchill on the west coast of Hudson Bay; on another (no. 1804) from the same place he wrote '*J. alpinus* Vill. H.W.P.'—contrast his earlier statement (in op. cit., p. 282) that '*J. alpinus* is unknown in North America', but cf. Lindquist (in tom. cit.). The former sheet I had originally determined in the Gray Herbarium as *J. alpinus* var. *rariflorus*, the latter as did Mr Pugsley.

these reports were of the typical form, but I know of no reason to doubt that var. *rari-florus* was the one actually collected. Yet another complication is that, unfortunately, it will probably be necessary to take up the name *J. alpino-articulatus* [Chaix apud?] Vill., Hist. Pl. Dauph. I, p. 378; 1786, for the more concise and more familiar name *J. alpinus*—see also Sprague in Journ. Bot. LXVI, p. 210; 1928.

[*JUNCUS SQUARROSUS* Linn. — Not seen—cf. Porsild (1930, p. 13).]

[*JUNCUS SUBTILIS* E. Meyer (*J. supinus* of American authors, not Moench—see Porsild, 1935, pp. 62–3) — Not seen for certain, and omitted by Porsild (1930, cf. pp. 13–14), although it has been found 'once in the Julianchaab district' (Porsild, 1935, p. 63). A sterile scrap (no. 10329) from Sydprøven may possibly be referable to this species.]

*JUNCUS BUFONIUS* Linn. — As usual varying greatly in form and luxuriance with micro-habitat conditions, being frequently only 1 cm. high even when upright whereas nearby specimens may attain 8 or even 10 cm. when only *weakly* ascending. My collections include no. 11399 from near the shore at Julianchaab, whence it has not previously been recorded. Indeed this may be only a recent introduction from Igaliko, where the species is plentiful and whence boats frequently ply to Julianchaab. I have also a note to the effect that during the same summer Eilif 'Dahl saw it at Qagssiarssuk, sparingly in a pathway'. This probably refers to Qagssiarssuk in Tun. Fj., but the report must not yet be taken as definite (cf. introduction).

*JUNCUS ALBESCENS* (Lange) Fernald — Although intermediates (hybrids?) occur, and indeed are to be expected where two such closely related species grow mixed together, this is generally distinct from *J. triglumis*, as was pointed out by Fernald (in *Rhodora*, xxvi, pp. 201 et seq., 1924, and xxxv, p. 236, pl. 249, 1933). Apparent hybrids were collected at Igaliko (no. 11273) and bet. Agd. & Ig. Fjords (no. 10554). Typical *J. albescens* was noted at the following new localities: Julianchaab (no. 10088); Sydprøven (no. 10275); Gl. Qagss. (nos. 10729, 10812a); Qag. in Tun. Fj. (not collected); Kingua in Tun. Fj. (no. 11043); Igaliko (no. 11256). From Gl. Qagss. '*Juncus triglumis* L.' was reported by Rosenvinge (1892, p. 713), but without mention of the 'variety'.

*JUNCUS TRIGLUMIS* Linn. (sensu str.) — Much less frequent than the last species—indeed rather rare, being found in full development only at Gl. Qagss. (nos. 10731, 10812).

[*JUNCUS BIGLUMIS* Linn. — Not seen. Omitted by Porsild (1930, cf. p. 13) but definitely reported by Lange (1880, p. 122) from Igaliko, and by others from within or very near our area.]

*JUNCUS TRIFIDUS* Linn. — Common.

*LUZULA PARVIFLORA* (Ehrh.) Desv. — Said to be common, but only seen a few times (usually well inland) during my wanderings in 1937. I could find no *L. spadiacea* (All.) DC. in the area or in collections from any other part of Greenland, although it is widespread in the Canadian Eastern Arctic and otherwise circumboreal.

'*LUZULA ARCUATA* Wahlenb.' — Mr Wilmott drew my attention to the fact that the SW. Greenland plant which has long passed under this name is not identical with the European one and may even require a new name, although this cannot be determined with the world in the present state. Thus my Greenland material differs from British specimens of *L. arcuata* in its broader and longer and straighter leaves and generally greater size; the 'heads' are larger and of a lighter brown, the branches of the inflorescence stiffer and more upright, and the whole plant is coarser, even if the capsules tend to be rather larger in the British plant. It is accordingly more reminiscent of the next species than is true *L. arcuata*. Although it was 'not seen' by the Porsilds, I collected it on Akul. (nos. 10342, 10415 pars), at the head of Igaliko Fjord near Gl. Qagss. (no. 10828), and bet.

Ig. & Jul. (no. 11330). It appeared to inhabit chiefly the lower-alpine zone, running both above and below into the more prevalent arctic *L. confusa* which is, however, generally quite distinct in the field. I am still very doubtful whether this distinction warrants specific segregation—cf. Sørensen (1933, p. 162), Gelting (1934, p. 217), and Seidenfaden & Sørensen (1937, pp. 106 & 166); probably the present plant is conspecific with the next and occupies an intermediate position between the true *L. arcuata* and *L. confusa*, which may perhaps themselves be conspecific (cf. Polunin, 1940, pp. 141–2).

*LUZULA CONFUSA* Lindeb. — Not rare. More or less typical specimens were collected at Kapisarko (no. 10001), Julianehaab (no. 10157), Sydprøven (no. 10271), on Akul. (no. 10427a), bet. Agd. & Ig. Fjords (no. 10553), on hills and mountains around Gl. Qagss. (e.g. no. 10829), and at Igaliko (no. 11299). It is among the hardiest of arctic plants, and often goes higher up mountains than any other vascular species (cf. Polunin, 1938, p. 91).

*LUZULA MULTIFLORA* (Retz.) Lejuncue — Not plentiful, and, in the usual absence of seeds, not easy to distinguish from the next. Such difficulties appear to arise not only in the area which I visited but also in south-east Greenland (according to Devold & Scholander, 1933, p. 112). Quite recently (ex Hultén, Fl. Aleutian Is. and Alaska, p. 125; 1937), Professor Samuelsson has reduced *L. frigida* to varietal rank again—this time under *L. multiflora* (cf. also Seidenfaden & Sørensen, 1937, p. 166). The following collections seemed to me referable to *L. multiflora* and were passed as such by the Greenland specialists in the Copenhagen Herbarium: no. 10146a from Julianehaab, no. 10223a from Sydprøven, and no. 10465 from Qagd. Mr A. J. Wilmott, however, informs me that they are all much darker than British plants, while the only seeds available (no. 10773 from Gl. Qagss., Igaliko Fjord—too young?) are much narrower (*more* than twice as long as broad) than in British material, all of which suggests a need for further study.

*LUZULA SUDETICA* (Willd.) DC. (*L. frigida* of recent authors)—aggr. — Common and extremely variable. This and the last species both produce analogous variations which make the determination of immature specimens difficult (cf. above). Some reduced forms are even superficially reminiscent of *L. nivalis* (Laest.) Beurl., which, however, appears to be absent from this extreme south-west portion of Greenland. The following collections I take to be typical: nos. 10879, 11224, and 11238 from Igaliko; no. 11395 from Julianehaab. In the absence of any conclusive demonstration that throughout most of its range 'the northern' *L. frigida* (Buchenau) Samuelsson ex Lindman is specifically distinct from *L. sudetica*, I continue to use the older name for the present complex whose relationship with *L. multiflora* and *L. campestris* (Linn.) DC. also needs elucidating.

*LUZULA SPICATA* (Linn.) DC. — Common. Variable in size and general appearance, the inflorescence being sometimes erect. In the mountains frequently failing to reach a height of 5 cm. even when in fruit.

## LILIACEAE

*TOPIELDIA PUSILLA* (Michx.) Persoon (based on *Narthecium pusillum* Michx. 1803, *teste* Stearn MS.; *T. palustris* of authors, see Polunin, 1940, p. 149; *T. minima* (Hill) Druce, nom. illeg.; *T. borealis* (Wahlenb.) Wahlenb., based on *Narthecium boreale* Wahlenb. 1805) — Common. The chief credit for unravelling the nomenclatural tangle surrounding this species lies with the Librarian of the Royal Horticultural Society, Mr W. T. Stearn, who will, it is to be hoped, shortly publish his findings in detail.

*STREPTOPUS AMPLEXIFOLIUS* (Linn.) DC. — Not common; found by me only a few times in or near previously known localities (including Ivigtut). Eilif Dahl has kindly sent me specimens which he collected the same year about 4 km. east of Sletten in Agdluitsog (Lichtenau) Fjord, which appears to be a new locality.

## ORCHIDACEAE

*ORCHIS ROTUNDIFOLIA* Banks ex Pursh (*Platanthera rotundifolia* (Banks) Lindl.) — Local. Once again found only around Gl. Qagss. (cf. Porsild, 1930, p. 14), whence, however, it extended some kilometres along the fjordside towards Igaliko.

*HABENARIA STRAMINEA* Fernald (*H. albida* of authors) — Common.

*HABENARIA HYPERBOREA* (Linn.) R.Br. (*Platanthera hyperborea* (Linn.) Lindl.) — Common, and so plastic that I cannot satisfactorily separate the varieties of Lange, at least among dried specimens from this area. When it grows with *H. straminea*, as is often the case (most notably on the lower slopes of Akuliaruserasuaq), there occur sterile leafy plants which may be hybrids between the two, but whose significance was unfortunately not realized in time for extensive study and collection.

*LISTERA CORDATA* (Linn.) R.Br. — Quite frequent. Additional localities: Borgs Havn (no. 10005); Qagd. (no. 10466); bet. Ig. & Jul. (no. 11353); Qanger. (no. 11371).

*CORALLORHIZA TRIFIDA* Chatel. emend. (*C. innata* R.Br.) — Infrequent, though found in small numbers, e.g. at Igaliko and Julianehaab. No new localities.

## SALICACEAE

*SALIX HERBACEA* Linn. — Common.

*SALIX UVA-URSI* Pursh (*S. Myrsinites* Linn. var. *parvifolia*<sup>1</sup> And.) — Fairly frequent. New localities: bet. Agd. & Ig. Fjords (nos. 10515, 10617); Igaliko (not collected).

*SALIX ARCTOPHILA* Cockerell apud Heller (*S. groenlandica* Lundstr., *S. chlorocladus* Floderus) — Plentiful in the marshes in most places. Unlike the situation in the Canadian Eastern Arctic (cf. Polunin, 1940, p. 159), this species in SW. Greenland appears to remain relatively constant, varying noticeably only in the shape and size of the leaves. Nor does it appear to hybridize at all frequently with the next species, even where the two grow side by side in the same marsh.

*SALIX GLAUCA* Linn. (sensu lat.) — Common. Extremely and tiresomely variable—most noticeably in habit and in the size, form, and hairiness of the leaves and fruits, so that numerous variants have been distinguished (e.g. by Lange, 1880, p. 110). Lange (1880, p. 111) also reports *S. lanata* from our area, but this was soon disclaimed by Rosenvinge (1892, p. 705). As to size, my no. 10400 from Akul. has leaves measuring, on the average, 2 by 0.5 cm., whereas in no. 10649 from Gl. Qagss. the leaves often exceed 5.5 cm. in length and 3.5 cm. in breadth.

Most of the SW. Greenland material that I have seen in herbaria is labelled *S. glauca* × *arctophila* or *S. glauca* × *arctophila* × *arctica*, but I cannot myself see such frequent admixture of *S. arctophila* or *S. arctica* and so prefer to use the above widely inclusive name in spite of the fact that none of the material is quite identical with Old World specimens of *S. glauca* (cf. Floderus in Medd. om Grønland, LXIII, pp. 121 et seq.; 1923). The range of variation seen in my SW. Greenland material is similar to that of the ill-defined *S. cordifolia* Pursh, which latter name ought possibly to be applied also to some of the West Greenland plants.

The leaves of *S. glauca* sensu lat. form the most important late summer and early autumn food of the local ptarmigan, whose crops sometimes contain nothing else at this season, although more often some *Polygonum viviparum* bulbils or *Empetrum* berries or odds and ends of other leaves are also to be found in them.

<sup>1</sup> Not *parviflora*, which is given by Rosenvinge (1892, p. 703).



## BETULACEAE

*ALNUS CRISPA* (Ait.) Pursh (*A. ovata* of authors) — Absent from most areas; cf. Grøntved (1938, p. 252).

*BETULA GLANDULOSA* Michx. — Common. Variable; but most at least of the varieties, etc., that have been proposed seem to have no more taxonomic importance than the size of the bush, which varies greatly according to local habitat conditions.

*BETULA PUBESCENS* Ehrh. (sensu lat.) (*B. odorata* Bechst. var. *tortuosa* (Ledeb. emend.) Rosenvinge). — Common away from the exposed sea-coast, and certainly indigenous in Greenland (cf. Trapnell in Journ. Ecol. xxi, p. 311, 1933, and Polunin, 1937, p. 940). The exact identity of the Greenland 'tree' birch is still obscure, even as its robustness and leaf characters are variable (the present category is inclusive of '*B. intermedia* Lange' and some other plants that have been reported from our area).

For a detailed discussion of which names should be applied to the Greenland representative or representatives of this collective species, see Porsild (1932, pp. 55 et seq.). It should, however, be noted that even if almost all of the thousands of individuals that I have seen in the field were immediately distinguishable from the local phases of *B. glandulosa*, there nevertheless occurred, both in the valleys and on the hills, occasional plants which showed characters of the latter species so strongly that they seemed to be of hybrid origin. Such plants included no. 10345a from Akul., no. 10458 from Qagd., no. 11287 from Igaliko, no. 11356 from bet. Ig. & Jul., and no. 11376 from Qanger. As noted by Porsild (1932, p. 57), such a hybrid complex 'would seem to cover what Rosenvinge had under the name *B. odorata* var. *alpestris*'; but this is not the same as *B. alpestris* Fries of Scandinavia, where *B. glandulosa* is unknown.

## POLYGONACEAE

*RUMEX DOMESTICUS* Hartm. — Growing to an unusual height (1½ m.) among the ruins at Igaliko, where it is well known to occur (cf. Lange, 1880, p. 106); also seen at Gl. Qagss., and in considerable abundance at Ivigtut, where, however, it is probably a relatively recent introduction. Not seen far from habitations or ruins (contrast Rosenvinge, 1892, p. 702).

*RUMEX ACETOSA* Linn. — Locally plentiful (cf. Rosenvinge, 1892, p. 702). Additional localities: Lichtenau (nos. 10438, 10442c); S. of Qag. in Tun. Fj. (no. 10906); Qag. in Tun. Fj. (locally plentiful); Kingua in Tun. Fj. (not collected); Kiagtut (not collected). It was already reported from 'Kekertarsuk ved Sydprøven 60° 29'' by Rosenvinge (1896, p. 70).

*RUMEX ACETOSELLA* Linn. — Common.

*OXYRIA DIGYNA* (Linn.) Hill — Common.

*KOENIGIA ISLANDICA* Linn. — Common except in the 'inner fjord' region, where it appeared to be lacking.

*POLYGONUM VIVIPARUM* Linn. — Common. As elsewhere (cf. Polunin, 1940, p. 177), the bulbils are much eaten by ptarmigan in August and September in this district. Like Rosenvinge (1892, p. 701), I too have seen 'bulbilli in planta matricali germinantes...'.

*POLYGONUM HETEROPHYLLUM* Lindm. var. *boreale* (Lange emend.) Lindm. (*P. aviculare* Linn. var. *boreale* Lange) — Common in most inhabited places, including Qagsimiut (cf. Rosenvinge, 1892, p. 701), Julianehaab (cf. Lange, 1880, p. 105), Sydprøven (no. 10289), Qagd. (no. 10477), and Qag. in Tun. Fj. (no. 11023). I have provisionally followed

Porsild (1930, p. 15, and 1932, pp. 28–9) and some other recent writers in applying the above combination of names, although further confirmation seems desirable. The SW. Greenland plant appears to be identical with much of my material collected the following year in Iceland, whence it may perhaps have been introduced by the Norsemen.

## CHENOPODIACEAE

[*ATRIPLEX* sp. — Not seen—see Porsild, 1930, pp. 15–16.]

## PORTULACACEAE

*MONTIA LAMPROSPERMA* Cham. (*M. fontana* of some authors). — Fairly common, at least around settlements. Collected at Qagsimiut (no. 10021), Julianehaab (cf. Lange, 1880, p. 32), Sydprøven (nos. 10191, 10186 pro parte), Qagd. (no. 10481), Igaliko (cf. Lange, 1880, p. 32), and Qag. in Tun. Fj. (cf. Porsild, 1930, p. 16).

? *MONTIA RIVULARIS* Gmel. — Some of my *Montia* specimens from Julianehaab (nos. 11386, 11442), and others seen growing at Sydprøven (*vide* Eilif Dahl), are upright (though rooting at the lower nodes) and unusually tall and luxuriant as well as being bright green and possessed of seeds with a very obviously marked and relatively dull surface. They thus fall nearer to *M. rivularis* Gmel. than to the usual *M. lamprosperma*, at least according to the characters given by Fernald & Wiegand (in *Rhodora*, XII, p. 138 and pl. 84; 1910). However, in view of the rather poor distinction of the species in some places, and of the paucity of authenticated material for comparison, I prefer for the present not to report *M. rivularis* as occurring in Greenland,<sup>1</sup> but to retain a query pending further study—especially in view of the fact that the specimens in question were all growing in manured or otherwise disturbed areas.<sup>2</sup> To these favourable habitat conditions some at least of the characters noted above may well be due; or again, the gatherings may have resulted from more recent introduction of seed or scraps. The Iceland material also appears to need revision (cf. Ostenfeld & Grøntved, 1934, p. 65).

## CARYOPHYLLACEAE

*STELLARIA MEDIA* (Linn.) Cyr. — Common in inhabited places.

*STELLARIA LONGIPES* Goldie — In the south, where it is relatively uncommon, this familiar arctic species differs both in habit and habitat from most northern material. Thus around Julianehaab it is more or less upright and occurs chiefly in the 'thickets', although in exposed places occasionally approaching the reduced f. *humilis* (Fenzl) Ostenfeld ex Grøntved—e.g. in no. 11278 from the mountain above Igaliko.

My no. 10954 from S. of Qag. in Tun. Fj. has the sepals much blunter as well as shorter and broader than is usual, though their shape is notoriously variable in this species (cf. Fenzl in Ledebour, Fl. Ross. I, pp. 386–8; 1842); more significant is the shape of the petals, which are broadly obovate though bipartite and scarcely longer than the sepals.<sup>3</sup>

<sup>1</sup> Whence it has indeed frequently been reported before (e.g. by Lange, 1880, p. 32, and 1887, p. 245; also by Rosenvinge, 1892, p. 667), but only in error for the usual *M. lamprosperma*, as I have confirmed from the specimens in the Arctic Herbarium at Copenhagen, the Gray Herbarium of Harvard University, and elsewhere (cf. Fernald, 1925, p. 273). The report by Rydberg (N. Amer. Fl. XXI, p. 316; 1932) is probably a mere repetition of these previous erroneous ones.

<sup>2</sup> Also, Druce (in Moss, The Cambridge British Flora, III, p. 5; 1920) named the plant *M. fontana* var. *intermedia*, while considering (p. 6) *M. rivularis* Gmel. to be 'partim' a state of 'var. *chondrosperma*' (Fernald & Wiegand's *M. fontana*).

<sup>3</sup> Similar plants were also seen, replacing the usual form over an area of many square metres, at an altitude of about 400 m. between the heads of Agdlutsoq and Igaliko Fjords. They were unfortunately not gathered.

They thus conform to the original description of the species by Goldie (in Edinb. Phil. Journ. vi, p. 327; 1822), in contrast to the usual run of material from northern localities which has the petals much narrower and longer. The distinction is striking in the field; but in the absence of any type material (in Herb. Edinburgh there appears to be no *Stellaria longipes* collected earlier than 1824, and none from anywhere in Ontario) I hesitate to add to the many—often worthless—varieties that have been proposed within this polymorphic species. It seems an apt subject for genetical study.

*STELLARIA HUMIFUSA* Rottb. — Common in its usual salt-marsh habitat. No. 11104 from Kiangtut is a peculiar form with more or less erect, much-branched and many-flowered inflorescences. It is sufficiently distinct to deserve a name: f. **multiflora** nov. forma. *Planta tota crassior quam in forma typica, plus minusve erecta, iterum atque iterum ramosa, subdichotoma saltem supra; foliis saepe 1 cm. longis; floribus numerosis et manifestis, saepe 7 per tertiarium vel aliud prominens ramum; pedicellis ut in forma typica unifloribus sed plerumque erectis et 1–1.5 cm. longis.*<sup>1</sup> Typus in Herb. Mus. Brit., co-typus in Herb. Fielding Univ. Oxon.: Nicholas Polunin, Kiangtut, Tunugdliarfik Fjord, no. 11104, 20–21 August 1937. The size of the lower leaves and the abundance of flowers suggest 'Lusus 1' of Fenzl's  $\alpha$  *oblongifolia* (in Ledebour, Fl. Ross. I, p. 384; 1842). However, as far as I have been able to determine in the absence of material for comparison, the present plant belongs rather to the usual 'eastern' series (cf. Polunin, 1940, p. 195). It may well be *Arenaria Purshiana* Ser. ex DC. (*A. thymifolia* Pursh 1814, not Sibth. 1806), described from 'the sea-shore of Labrador'; it may also be to some such plants that Hultén (in Kungl. Svenska Vetensk.-Akad. Handl. ser. 3, v, no. 2, p. 67; 1928) referred when noting in 'Greenland material... specimens resembling our plant' (var. *oblongifolia* Fenzl). However, if var. *oblongifolia* and f. *multiflora* (?) represent mere *formae luxuriosae* in the manner suggested as possible by Hultén (loc. cit.), then they are quite striking ones.

*STELLARIA CALYCANTHA* (Ledeb.) Bong. (*Arenaria calycantha* Ledeb. 1812, *Stellaria borealis* Bigel. 1824—see Hultén, op. cit., p. 64, and cf. Fernald in Rhodora, XLII, pp. 254 et seq.; 1940) — Common.

*CERASTIUM CERASTOIDES* (Linn.) Britton (*C. trigynum* Vill.) — Common.

*CERASTIUM ALPINUM* Linn. (sensu lat.) — Common. Extremely variable, as usual in northern regions, but unlike the situation in the Canadian Eastern Arctic (cf. Polunin, 1940, pp. 186 et seq.) and some other areas, it seems in SW. Greenland to be separable into three distinct forms:

(i) The common, usual phase represented by my nos. 10059 from Julianehaab, 10195 and 10200 from Sydproven, 10396 from Akul., 10470 from Qagdl., and 10825 from Gl. Qagss. These are all more or less glandular-hairy and so cannot be referred to the typical form although they come very near to it (cf. Fernald & Wiegand in Rhodora, XXII, p. 171; 1920).

(ii) A fresh green, caespitose, much less hairy but still glandular form with unusually large flowers occurring in the mountains. The specimens, of which examples are my nos. 10409 and 10427 d from Akul. and no. 11328 from a high mountain pass bet. Ig. & Jul., match others in Herb. Copenhagen determined by Johs. Lange as his *Cerastium arcticum*. This has frequently been maintained as a distinct species but is probably only a phase of the polymorphic *C. alpinum* (cf. Gelting, 1934, p. 36). The name for the European segregate which has been called *C. arcticum*, and which has still shorter and blunter sepals

<sup>1</sup> i.e. 'The whole plant coarser than in the typical form, more or less upright, repeatedly branched, subdichotomous at least above, with the leaves often 1 cm. long; with flowers numerous and conspicuous, often 7 per tertiary or other prominent branch; pedicels as usual 1-flowered but mostly erect and 1–1.5 cm. long.'

than my specimens,<sup>1</sup> and almost glabrous basal leaves, should according to Gelting (loc. cit.) be '*C. Edmonstonii* (Wats.) Murb. et Ostf.' This must, however, be written *Edmondstonii*, as the plant was named after Thomas Edmondston (1825-46), author of the 'Flora of Shetland'.

(iii) In several places in the lowlands there occurs a woolly-white form that except for its slight glandulosity (see Fernald & Wiegand in *Rhodora*, xxii, p. 172; 1920) would be referable directly to var. *lanatum* (Lam.) Hegetschw. Examples are my nos. 10754 from Gl. Qagss., 10868 from Igaliko, and 11130 from Kiagtut.

*CERASTIUM VULGATUM* Linn. (*C. caespitosum* Gilib., nom. illeg.) — Quite frequent. As far as I could make out during the rather late season of my visit, and contrary to the indications by Porsild (1930, p. 16), the long-petalled var. *alpestre* (Lindbl.) Hartm. was far less frequent than the short-petalled typical form. Indeed, according to Mr Wilmott, all the specimens I brought back are directly referable to the latter. They often exceed 35 cm. in height. New localities: Qagdl. (no. 10464); Qag. in Tun. Fj. (not collected).

*SAGINA NODOSA* (Linn.) Fenzl — Abundant at Igaliko and common enough at Qag. in Tun. Fj., but otherwise found only S. of Qag. in Tun. Fj. (no. 10953), at Kingua in Tun. Fj. (no. 11053), and at Qanger. (no. 11378). Porsild (1930, p. 16) reported this species from 'Qagssiarssuk, Ig. F.', i.e. Gl. Qagss.; but although I searched acres of ideal, more or less open, dry sandy habitats in this place I could not find a single specimen, whereas at Qag. in Tun. Fj. the plant was plentiful. Consequently I cannot help thinking that the two Qagssiarssuks must have been confused by Porsild's editor or typesetter (cf. the case of *Rorippa*, p. 386 below).

[*SAGINA CAESPITOSA* (J. Vahl) Lange — Not seen by the Porsilds or by me, but reported by Rosenvinge (1892, p. 663) from several places. As has already been pointed out (Polunin, 1940, p. 206), and as was kindly confirmed by an examination of the type specimen by my brother Ivan Polunin, of Queen's College, Oxford, during a recent visit to Copenhagen, this plant has nothing to do with *S. intermedia* Fenzl (*S. nivalis* (Lindbl.) Fries, nom. confus.). Thus the chief reason for the persistent application of the name '*Sagina caespitosa*' to the latter plant, for example by Druce in his 'British Plant List' (ed. 2) and 'Comital Flora' and by Wright (in *Journ. Bot.* lxxvi, suppl. pp. 1-8 and pls. 1-15; 1938), appears to be the absence of true *S. caespitosa* from the British flora and from most herbaria!]

*SAGINA INTERMEDIA* Fenzl (*S. nivalis* (Lindbl.) Fries, nom. confus.) — Infrequent as well as insignificant. Found only at Josua-Minen (no. 10007), and in two places bet. Ig. & Jul. (nos. 11324, 11355).

*SAGINA SAGINOIDES* (Linn.) Karsten (*S. Linmaei* Presl) — Apparently scarce, the vast majority of the specimens which in the field I had thought probably belonged to this species being referable rather to the next, as has been kindly confirmed by Messrs A. J. Wilmott and J. P. M. Brenan. However, the following specimens were gathered: Borgs Havn (no. 10004b); Julianehaab (nos. 10067 pars, 10119, 11426 pars). From the latter place it was reported by Lange (1880, p. 21).

*SAGINA PROCUMBENS* Linn. — Evidently fairly common, though 'not seen' by the Porsilds. Collected by me at Borgs Havn (no. 10004), Julianehaab several times (here it was early found by Jens Vahl—cf. Lange, 1880, p. 21), Qagdl. (no. 10457), Igaliko (nos. 10845, 10856—here again it has been found before), S. of Qag. in Tun. Fj. (no. 10918), and bet. Ig. & Jul. (no. 11354). No. 10172 from Julianehaab is small and moss-like and has

<sup>1</sup> These have, however, the completely herbaceous bracts characteristic of the segregate (*vide* A. J. Wilmott).

very tiny flowers, with sepals regularly only about  $1\frac{1}{2}$  mm. long. However, specimens in my other collections from Greenland and elsewhere show transitions from this to the normal state, and suggest mere local starvation as the cause of dwarfing.

*ARENARIA SAJANENSIS* Willd. apud Schlecht. (*Minuartia biflora* (Linn.) Schinz & Thell., *Stellaria biflora* Linn. 1753, not *Arenaria biflora* Linn. 1767) — Evidently rare, or at least extremely local. Not found by the Porsilds, and by me encountered only at rather high altitudes (chiefly above 1200 m.) on Akul. (nos. 10344, 10422).

*ARENARIA RUBELLA* (Wahlenb.) Sm. (*A. hirta* Wormskj., *A. propinqua* Richardson, *A. verna* Linn. var. *pubescens* (Cham. & Schl.) Fernald, *Minuartia rubella* (Wahlenb.) Gracbn.) — Quite common, being collected or noted on more than a dozen occasions almost throughout the area traversed; hence it would be superfluous to list 'new' localities. Very variable, enclosing within its general form-series some well-marked phases including entities that have been proposed as separate species but surely cannot be maintained as such (cf. Fernald in *Rhodora*, xxi, p. 21; 1919).

[*ARENARIA GROENLANDICA* (Retz.) Spreng. (*Minuartia groenlandica* (Retz.) Ostenfeld) — Not seen. This attractive species has, however, long been known from southern Greenland (cf. Lange, 1880, p. 26, and Rosenvinge, 1892, p. 664), whence it extends westwards in subarctic Canada to the east coast of Hudson Bay (Polunin, 1936 field notes) and southwards into the north-eastern United States (cf. Fernald in *Rhodora*, xxi, pp. 17–21; 1919).]

*ARENARIA HUMIFUSA* Wahlenb. (*A. cylindrocarpa* Fernald) — Evidently rare. Clearly Wahlenberg's 'lost species' and not the East Greenland *A. ciliata* Linn. subsp. *pseudofrigida* Ostenfeld & Dahl, as was kindly confirmed for me by Dr M. P. Porsild who pronounced my one collection (no. 11373 from Qanger.) to be good and typical. Not found previously on the west coast of Greenland south of Godhavn, Disko Island, and hence a great 'range extension'. This and my recent finds in the Canadian Eastern Arctic (Polunin, 1940, pp. 198–9) are particularly interesting in view of the manner in which the species has been made the text for discussions on 'persistence' (e.g. by Nordhagen, 'Om *Arenaria humifusa* Wg. og dens betydning for utforskningen av Skandinaviens eldste floraelement', in *Bergens Mus. Årbok, Naturvid. rekke*, no. 1, pp. 1–183 and plates; 1935). As with some other diminutive or previously unrecognized species, the conclusion would now appear inescapable that its fame for having a 'disrupted distribution' (cf. Fernald, 1925, pp. 252–3) is dependent partly on its being somewhat calciphilous and still more on its having been overlooked by most collectors in areas where actually it occurs. This does not, however, necessarily mean that such species have not persisted in the same or similar spots for hundreds or even thousands of years; they may well have done so, in the virtual absence of competition.

*ARENARIA PEPLOIDES* Linn. (*Hqnkenya* (Honckeneja, etc.) *peploides* (Linn.) Ehrh., *Ammadenia* (Ammodenia) *peploides* (Linn.) Rupr.) — Can hardly be common in the region traversed, although of course confined to the sea-shore. My only collection, no. 11049 from near the head of Tun. Fj., belongs to the usual northern var. *diffusa* Hornem. (cf. Lange, 1880, p. 26 sub nom. *Halianthus*).

*LYCHNIS ALPINA* Linn. (*Viscaria alpina* (Linn.) G. Don) — Common. The pale-flowered phase (f. *albiflora* Lange, 1880, p. 19, sub nom. *Viscaria*) also occurs, but not at all commonly in the district I traversed (contrast Porsild, 1930, p. 16). My material belonging to this species is so variable in luxuriance and in the size of the parts that specimens referable to both var. *typica* and var. *americana* Fernald are to be seen even in the same collection. Moreover, as Mr Wilmott can find no constant difference between American and European

material in the British Museum, and as I have noted European specimens in the Fielding Herbarium of Oxford University with large radical leaves and up to six pairs of cauline ones, we are inclined to think that the two varieties (see Fernald in *Rhodora*, XLII, pp. 259–60; 1940) may after all represent mere 'ecological' extremes.

*SILENE ACAULIS* (Linn.) Jacq., Enum. Stirp. Vindob. p. 242; 1762 — Common. All the material from SW. Greenland that I have seen is referable to the typical form and not to the usual arctic American var. *exscapa* (All.) DC., which is, however, approached on the exposed coast and on high mountains (cf. no. 10407 from Akuliaruserssuaq). N. J. Jacquin's combination under *Silene* apparently antedates Linnaeus' (Sp. Plant. ed. 2, 1), since in the introduction to the latter's work, Jacquin's work seems already to be cited under 'Auctores' as 'Flora Vindelic... 1762 Oct.'—cf. the species referred to by Linnaeus in the appendix to his second volume where 'Jacq. Vind.' frequently occurs with pages referring to the Enum. Stirp. Vindob.

### RANUNCULACEAE

*COPTIS GROENLANDICA* (Oeder) Fernald (*C. trifolia* Salisb. in part) — Common.

*RANUNCULUS REPTANS* Linn. — Quite common—cf. Porsild (1930, p. 16). I collected it at Sydprøven (no. 10336) and inland from Qagd. (nos. 10556, 10581), as well as on numerous occasions around Igaliko and Tunugdliarfik Fjords. Usually submerged, at least in early summer: contrast Benson in Bull. Torrey Bot. Club, LXIX, p. 306; 1942, sub nom. *R. Flammula* var. *filiformis*.

*RANUNCULUS HYPERBOREUS* Rotth. — Occurs chiefly near the outer coast; like Rosenvinge (1892, p. 676), I failed to find it far inland. Additional locality: Sydprøven (no. 10187).

*RANUNCULUS PYGMAEUS* Wahlenb. — Not at all frequent even in the mountains. Additional locality: Akul. (no. 10411).

*RANUNCULUS ACERIS* Linn. — Common. Rarely if ever eaten by the sheep—cf. Avebury, Notes on the Life History of British Flowering Plants, p. 57; 1905. There appears, fortunately, to be no need to change the Linnean spelling to 'acer' in the manner so frequently followed on the Continent.

*RANUNCULUS TRICHOPHYLLUS* Chaix apud Vill. var. *eradicatus* (Laest.) W. B. Drew (*R. confervoides* Fries) — Fairly common, and collected at the following 'additional'<sup>1</sup> localities: Sydprøven (nos. 10221, 10233); bet. Agd. & Ig. Fjords (no. 10611); Qag. in Tun. Fj.<sup>1</sup> (no. 10982); Kingua in Tun. Fj.<sup>1</sup> (nos. 11046, 11080); Kiagtut (11198).<sup>1</sup> The specimens are very variable in size and luxuriance, and far from constant even in the size of the flowers, collapsibility (but mostly collapsing) of the leaf segments, and the 'webbing' and hairiness of the fruitlets; but all appear to belong to the one species (cf. Butcher in Proc. Linn. Soc. Lond., Sess. 152, p. 180; 1940) and most of them to the above variety which is the usual one in arctic and subarctic as well as high-alpine regions. However, some plants from the most favourable, sheltered habitats approach the typical form (cf. Drew in *Rhodora*, XXXVIII, pp. 12 et seq.; 1936). To this latter series, it seems probable, belongs also the 'rather deviating form' tentatively reported as *R. divaricatus* Schrank by Porsild (1920, p. 77) from much farther north in West Greenland.

*THALICTRUM ALPINUM* Linn. — Common.

<sup>1</sup>Already reported by Lange (1880, p. 54) from somewhere in Tun. Fj., but without precise locality, and by Rosenvinge (1892, p. 676) from Qordlortoq in the same fjord.

## PAPAVERACEAE

*PAPAVER RADICATUM* Rottb. (*P. nudicaule* of authors, not Linn.) — Seems to be infrequent rather than actually rare, although conspicuous. Already recorded from many localities, and by me found at three apparently new ones, viz. Akul. (leaves only, not collected), Kiagtut (no. 11171), and Igaliko (no. 11298). Dr A. C. Fabergé, to whom I sent seed from the Kiagtut and Igaliko gatherings (and also of the white-flowered form from farther north, given me by Dr M. P. Porsild), reported that none germinated. It also seems not inappropriate here to note that since the appearance of Part I of my 'Botany of the Canadian Eastern Arctic', Dr Fabergé has reported (in lit.) as follows on material which I sent him from various parts of that area in 1936: 'It is all octoploid ( $2n=56$ ). Other material from British Columbia, and Utah, was hexaploid ( $2n=42$ ). Icelandic material is  $2n=70$ , and so is most of the Scandinavian... though 56 is found too.' See also Fabergé in Journ. Genetics, XLIV, p. 169; 1942.

## CRUCIFERAE

*SUBULARIA AQUATICA* Linn. — Qag. in Tun. Fj. (no. 11030), which is a new locality for a plant that has been found only a very few times before in Greenland. Markedly dwarfed, and still in the flowering or only early fruiting stage on 17 August.

*COCHLEARIA OFFICINALIS* Linn. (sensu lat.) — Common and as usual extremely variable. Most of my specimens appear to fall within the limits of (or at least near to) var. *groenlandica* (Linn.) Gelert apud Andersson & Hesselman, but some (e.g. no. 10175 from Julianehaab) are referable rather to var. *oblongifolia* (DC.) Gelert apud Andersson & Hesselman, which, however, may perhaps be a mere luxuriant phase of var. *groenlandica* (cf. Polunin, 1940, p. 226).

*RORIPPA ISLANDICA* (Oeder ex Murr.) Borbás — See Fernald (in Rhodora, XLII, pp. 267 et seq.; 1940) for a discussion and citations of other recent papers dealing with the nomenclature of this plant, which for a long time was recorded from Greenland as '*Nasturtium palustre* (L.) R.Br.' Extremely local, being found by me only about the ruins of Eric the Red's estate Brattahlíð at Qag. in Tun. Fj. Here it is very plentiful and, as indicated by specimens in the Copenhagen Herbarium, has often been found before—and it was here (*fide* M. P. Porsild and cf. distributed labels) that it was collected by the Porsilds in 1925, so the report (Porsild, 1930, p. 17) from 'Qagssiarssuk, Ig. F.' (i.e. from Gl. Qagss.) is an error (cf. *Sagina nodosa* above), as I already began to think after searching there for many hours in all the likely spots I could find. Even in the one locality where I found it this highly plastic species varied greatly in size and habit according to the local conditions, and also in the shape of the siliques.

*CARDAMINE PRATENSIS* Linn. var. *angustifolia* Hook. — Additional locality: Sydprøven (no. 10308). At Lichtenau there occurred specimens (no. 10428) with whitish flowers and other characters of var. *palustris* Wimm. & Grabow. This was found in full development at Qag. in Tun. Fj. (no. 11103), whence it has already been recorded (Porsild, 1930, p. 17).

*CARDAMINE BELLIDIFOLIA* Linn. — Rather rare, and apparently confined to the mountains. Found by me several times on Akul. (nos. 10424, 10427e) and twice at the head of Igaliko Fjord near Gl. Qagss. (no. 10826); also elsewhere the same summer by the Dano-Norwegian expedition (see Grøntved, 1938, pp. 252–3).

*CAPELLA BURSA-PASTORIS* (Linn.) Medic.<sup>1</sup> — Locally abundant in the settlement at Julianehaab, where it has long been known to occur (cf. Lange, 1880, p. 45). Probably a

<sup>1</sup> Friedrich Casimir Medicus (or F. K. Medikus), 1736–1808. The original publication being unavailable to me, I have followed the 'Catalogue of the Library of the British Museum (Natural History)', vol. III, 1910, in using the above spelling.

relatively recent introduction here, as it may also be at Qag. in Tun. Fj., where I saw a few plants growing. A collection made in the latter place by A. E. and M. P. Porsild on 10 August 1925 was distributed as *Thlaspi arvense* Linn.

**DRABA INCANA** Linn. — Common. Very variable in the size and form of the fruit and also of the whole plant, as elsewhere. Specimens with queer small fruits (averaging 1.6 by 6 mm. including style) that may just possibly be referable to the next species, which has been reported from our area, were found at Kragtut (nos. 11116, 11138). The late Mrs Ekman (in Svensk Bot. Tidskr. XXIX, p. 351; 1935) remarked of *D. incana* that it 'contains several different forms or races which are proved to be constant under culture'.

[**DRABA STYLARIS** J. Gay (*D. Thomasii* Koch) — A rather doubtful species (cf. Fernald in Rhodora, XXXVI, p. 359; 1934); according to O. E. Schulz (in Engl. Pflanzenreich, 89 (iv, 105)—Cruciferae—*Draba* et *Erophila*, p. 287; 1927) it represents a mere phase of *D. incana* and is confined to Europe and the Caucasus. Its occurrence in our area is certainly problematical—see above. Nor do I know to what Lange (1880, p. 42) was referring when he reported a variety of '*D. corymbosa* R.Br.' from our area—cf. also Rosenvinge (1892, p. 671) and Polunin (1940, footnote on p. 226).]

**DRABA AUREA** M. Vahl — Said to be common, but individuals are nothing like as numerous as in the case of *D. incana*. Thus I came across it only ten times (spread over almost as many localities) in 1937, although I must have walked some hundreds of kilometres and could scarcely have failed to notice so conspicuous a plant whenever it occurred along my route.

**DRABA NIVALIS** Liljebl. — Fairly frequent but never numerous. Small and insignificant. Not seen by the Porsilds but collected by me at Julianehaab (cf. Lange, 1880, p. 40), Akul. (nos. 10398, 10421) where it was seen many times and persisted well above 1200 metres, Lichtenau (no. 10451a), bet. Agd. & Ig. Fjords (no. 10544), Gl. Qagss. (no. 10721), and Kragtut (no. 11176).

**DRABA RUPESTRIS** R.Br. — Apparently not previously known to occur quite within this region, but found by me several times on mountains or near waterfalls (the identifications were kindly confirmed by Eilif Dahl of Oslo) as follows: Akul. (no. 10426); Qagd. (no. 10475b); bet. Ig. & Jul. (nos. 11323, 11329, 11340). I much regret the error, based on a hasty field determination, of reporting the first found specimens as *D. glabella* Pursh. This was in a special number of the native journal *Sujumut*, produced to commemorate the climb up Akuliaruserssuag, and, although I have not seen a copy, some appear likely to have reached civilization. Concerning my specimens cited above Mr A. J. Wilmott writes (in lit.): 'As Syme says, the British material has the stems leafless or more rarely with a single leaf. Much of the extra-British material referred to *D. rupestris* has, however, stems with two or several leaves. But the habit, foliage, indumentum, flower, fruit and style of these Greenland and other specimens are so close to those of the Ben Lawers plant, which itself shows quite an amount of variation in several directions, that I think one must pass these leafy-stemmed plants as *D. rupestris* exhibiting—like many other species—a greater degree of variation outside the British Isles than the British Isles themselves can show.'

**ARABIS ALPINA** Linn. — Fairly frequent, especially around waterfalls.

**ARABIS HOLBOELLII** Horn. — Not found by me, but collected the same summer by Eilif Dahl of the Dano-Norwegian expedition at Rosenvinge's old locality of Qordlortoq in Tun. Fj.—cf. Grøntved (1938, p. 252) and Rosenvinge (1892, p. 673).



*ARABIS ARENICOLA* (Richardson) Gelert — Not, as has been thought, entirely new to SW. Greenland, for whether or not the mysterious '*Lepidium groenlandicum* Horn.', rather hesitatingly reported by Lange (1880, p. 45, and 1887, p. 250), belongs to it, '*Sisymbrium humifusum* J. Vahl', which is no more than a synonym of *A. arenicola*, has long been known from Gl. Qagss. in Igaliko Fjord (cf. Lange, 1880, p. 52), while '*Arabis humifusa* (J. Vahl) Wats.' was reported by Rosenvinge (1892, p. 674) from Kingua in Tun. Fj. My specimens are poor as I only found a few scraps—again at Gl. Qagss. (on a sand-bank near the sea) and at the new locality of Kiagtut (no. 11142). At the latter place Grentved (1938, p. 252) found it the same year in much greater numbers; he also reports it from two places in Bredefjord (coll. Louis Jensen).

## DROSERACEAE

*DROSERA ROTUNDIFOLIA* Linn. — Found growing in open patches of damp moss in a birch thicket on the side of a hill a few kilometres in a north-easterly direction from Igaliko. The specimens were locally plentiful and looked as though they would ripen seed successfully. The only specimens in the Copenhagen Herbarium from Greenland are on a single sheet collected by L. K. Rosenvinge in 1888 and labelled 'Igaliko l. Ved en S6 100' h. 24 Jul. 2. Mell. Mosser v. en S6 30 Jul.' It seems as though they may have come from the self-same hill as did mine, and that the species may conceivably occur nowhere else in Greenland.

## CRASSULACEAE

*SEDUM ROSEA* (Linn.) Scop. (*S. Rhodiola* DC., *Rhodiola Rosea* Linn.) — Common. The leaves are much eaten by the natives.

*SEDUM VILLOSUM* Linn. — Fairly frequent. Collected at the following additional localities: Lichtenau (nos. 10341 b, 10447); bet. Agd. & Ig. Fjords (no. 10634); Kingua in Tun. Fj. (no. 11052); Kiagtut (no. 11179); bet. Ig. & Jul. (no. 11359).

*SEDUM ANNUUM* Linn. — Common.

## SAXIFRAGACEAE

*PAENASSIA KOTZEBUEI* Cham. & Schlecht. — Little known in Greenland; thus in the Arctic Herbarium at Copenhagen there were as recently as 1937 only three sheets from this 'continent', collected by Jens Vahl, Rosenvinge, and the Porsilds, and they all came from Igaliko Fjord—either from Gl. Qagss. or from Igaliko itself. I do not think it can be at all plentiful in the latter place as I did not see it there on either of my visits; but I found it four times around Gl. Qagss., including once by a lake several kilometres inland.

*SAXIFRAGA AIZOON* Jacq. — Common.

*SAXIFRAGA OPPOSITIFOLIA* Linn. — Common.

*SAXIFRAGA STELLARIS* Linn. — Common except around the heads of the larger fjords. It was in vain that I searched for the usual arctic var. *comosa* Retz., although this has long been known from 'Kingua Neriak 61° 35' (Hartz)!' (see Rosenvinge, 1892, p. 678) not so far to the north-west of Ivigtut.

*SAXIFRAGA NIVALIS* Linn. — Fairly common. There also occur very occasional specimens (e.g. no. 11335 collected by a fine waterfall on the journey from Igaliko to Julianehaab) that seem best referred to var. *tenuis* Wahlenb. (*Saxifraga tenuis* (Wahlenb.) H. Smith, *S. stricta* Hornem.), cf. Devold & Scholander (1933, p. 32). These specimens,

although not quite conforming with high-arctic ones, come near to them and are inseparable from Jens Vahl's material from Igaliko reported by Lange (1880, p. 60) as '*β, tenuior* Wahlenb.' and verified by H. Smith in 1918 as *S. tenuis*.

*SAXIFRAGA AIZOIDES* Linn. — Not common except at Gl. Qagss.; but not really rare in the region traversed. Noted at the following new localities: bet. Agd. & Ig. Fjords (nos. 10538, 10644); Qag. in Tun. Fj. (no. 10975); Kingua in Tun. Fj. (not collected); Qanger. (not collected).

*SAXIFRAGA CERNUA* Linn. — Rather infrequent, even in the mountains. Additional localities: Akul. (no. 10389); bet. Agd. & Ig. Fjords (no. 10558); bet. Ig. & Jul. (no. 11331); and possibly? Kingua in Tun. Fj. (scrap found among specimens of *Sedum villosum*, no. 11052, but not noted or remembered). According to my field note-book, one colony seen bet. Agd. & Ig. Fjords included a specimen of '*f. ramosa* Gmel.' (see Polunin, 1940, footnote on p. 254).

*SAXIFRAGA RIVULARIS* Linn. — Not as rare as has recently been supposed—it was long ago dismissed as 'almindelig' by Lange (1880, p. 62)—but rather overlooked on account of its small size. Collected at the following additional localities: Julianchaab (nos. 10098, 10134); Sydproven (nos. 10227a, 10266); Akul. (nos. 10382b, 10427); bet. Ig. & Jul. (no. 11344). The specimens show the usual variations in habit, hairiness, and flower colour (cf. Polunin, 1940, p. 252).

*SAXIFRAGA CAESPITOSA* Linn. (*S. groenlandica* Linn., *S. decipiens* of some authors) — Fairly common, even in the lowlands.

## ROSACEAE

*SORBUS DECORA* (Sarg.) C. K. Schn. — Widespread in the more luxuriant thickets around the heads of the fjords, but not always present even there, and rarely persisting more than a few hundred feet up the mountains.

[*RUBUS CHAMAEMORUS* Linn. — Not seen—cf. Porsild (1930, p. 18).]

[*RUBUS SAXATILIS* Linn. — Not seen—cf. Porsild (1930, p. 18).]

*POTENTILLA PALUSTRIS* (Linn.) Scop. (*Comarum palustre* Linn.) — Not really rare. Noted in the following fresh localities: Sydproven (no. 10287); Kiagtut (no. 11122). Also frequent in other parts (especially around Qag.) of Tun. Fj., whence it has long been known (cf. Lange, 1880, p. 3, and Rosenvinge, 1892, p. 654). My material is all referable to the reduced northern phase which may be called var. *parvifolia* (Raf.) Fernald & Long, although with only doubtful advantage (see Polunin, 1940, p. 284).

*POTENTILLA CRANTZII* (Cr.) Beck (*P. maculata* Pourr., *P. alpestris* Hall. fil.) — Common. Far less plentiful (cf. Lange, 1880, p. 6), and growing chiefly on or around the old Norse ruins, is var. *hirta* (Lange) Malte. This is *Potentilla Langeana* Rydberg, but is not, I think, the same as the less distinct Labrador plant in whose favour Malte made his transfer—see Malte (in *Rhodora*, xxxvi, p. 173; 1934), and cf. Polunin (1940, p. 274). My material from ruins a few kilometres inland of Gl. Qagss. (nos. 10590, 10594), as well as that from Igaliko (no. 11277) and Kiagtut (nos. 11141, 11150), compares very well with Lange's type specimen of his original *P. maculata* *β hirta*, which may indeed represent a separate species, as was postulated by Rydberg (in *Bull. Torrey Bot. Club*, xxviii, p. 179; 1901). Certainly the two appear abundantly distinct in the field.

The name *Potentilla Crantzii* is based on '*FRAGARIA crantzii*' (sic) Crantz, *Instit. Rei Herb.* ii, p. 178, 1766.

*POTENTILLA RANUNCULUS* Lange — Not seen growing, but I was shown fresh specimens collected by Eilif Dahl of the 1937 Dano-Norwegian expedition near the head of Tun. Fj. — apparently new to SW. Greenland (cf. Grøntved, 1938, p. 253).

*POTENTILLA NIVEA* Linn. — Apparently new to this region, although long known from Jensen's Nunatak not so very far to the north-west—cf. Lange (1887, p. 235) and Rosenvinge (1892, p. 656). Found twice by me on Akul. (nos. 10386, 10409a), and elsewhere in the district by the Dano-Norwegian expedition, but always well up on the mountains (cf. Grøntved, 1938, p. 253).

*POTENTILLA EGEDII* Wormskj. (See Polunin, 1940, p. 283) — The northern, glabrous or glabrate *forma typica* appears to come thus far south only on the exposed coast or in otherwise unfavourable places. It was collected at Sydproven (no. 10290) and on wave-washed mudflats at Qagd. (no. 10476). Much more frequent, and sometimes growing mixed with the typical form although even then only occasional intermediates are to be seen thereabouts, is the more robust, white-hairy var. *groenlandica* (Tratt.) Polunin (*P. pacifica* Howell, *P. Anserina groenlandica* Tratt.). Examples of this come from Julianehaab (no. 10101), Sydproven (no. 10236), and Igaliko (nos. 10838, 10839).

[*POTENTILLA ANSERINA* Linn. — Not seen—cf. Porsild (1930, p. 18). The occurrence of this species in Greenland still needs confirming—see Porsild (1932, p. 16).]

*POTENTILLA TRIDENTATA* Soland. ex Ait. (*Sibbaldiopsis tridentata* (Soland.) Rydberg) — Common. Varies markedly in hairiness.

*SIBBALDIA PROCUMBENS* Linn. — Fairly frequent in the uplands (e.g. Akul., nos. 10410, 10426b, and on a mountain pass near Qagd., no. 10475), and descending almost to sea-level nearer the exposed ocean coast (e.g. at Qagsimiut, no. 10015, Julianehaab, no. 10048, and Sydproven, no. 10253). From Julianehaab it has been known since the days of Jens Vahl—see Lange (1880, p. 11). Also observed near Igaliko, and several times during the course of a trek from the latter place to Julianehaab.

*DRYAS INTEGRIFOLIA* M. Vahl — Scarce indeed. Localities additional to those given by Porsild (1930, p. 18) are: bet. Agd. & Ig. Fjords (nos. 10526, 10618); Qag. in Tun. Fj. (no. 11103a). In lowland situations here in the South it seemed to have had its usual early flowering so upset that plants were often to be found in bloom or even in bud as late as August, when all stages up to ripe fruit were sometimes to be seen on a single tuft.

*ALCHEMILLA ALPINA* Linn. — Common.

*ALCHEMILLA FILICAULIS* Buser (*A. minor* subsp. *filicaulis* (Buser) Lindb. fil.) — Localities additional to those given by Porsild (1930, p. 18) are: Qagd. (no. 10467); Igaliko (no. 11295). My determinations were kindly confirmed by Eilif Dahl of Oslo. *A. pseudominor* Wilmott (*A. minor* of authors, not Huds.) was reported from Julianehaab by Lindberg (in Acta Soc. Sci. Fennicae, xxxvii, 10, p. 92; 1909, sub nom. *A. minor*).

*ALCHEMILLA GLOMERULANS* Buser — Evidently not rare. Fresh localities (i.e. additional to those confirmed since this species was recognized): Julianehaab (no. 10151); Akul. (nos. 10361, 10362, 10391?); bet. Agd. & Ig. Fjords (no. 10491); Qag. in Tun. Fj. (nos. 10973, 10977).

*ALCHEMILLA ACUTIDENS* Buser — Seen growing as an introduction at Ivigtut (*vide* Eilif Dahl, who has also sent me a specimen which he collected the same summer at Julianehaab).

## LEGUMINOSAE

*Vicia Cracca* Linn. — Found again at Igaliko, where it seems to be extremely local (cf. Rosenvinge, 1892, p. 653). The plants were stated by Porsild (1930, p. 18) to be 'dwarfish and sterile' (in 1925), but in 1937 they were flowering well enough, as was also the case with other Igaliko specimens taken previously that I have seen in herbaria. Moreover, on a plant collected there by Jens Vahl on 5 August 1828, there are well developed fruits on one axis and in one pod a single large seed-bulge. The species is said to have been found recently at Qag. in Tun. Fj., but I have seen no confirmatory specimens.

*Lathyrus Japonicus* Willd. (incl. *L. maritimus* Bigel., etc.) — Almost entirely glabrous material (the typical form—cf. Fernald in Rhodora, xxxiv, p. 178; 1932) was found only at Igaliko (no. 11312), and there only around high water-mark along a limited tract of shore below the bishop's bath. Fernald (in tom. cit., p. 180) implies that it is relatively rare in Greenland. The usual northern plant is the more or less hairy var. *aleuticus* (Greene) Fernald, to which all the rest of my material is referable. This is common in the regions traversed, and is frequently to be met with at a considerable distance from any salt water—e.g. near Gl. Qagss. where it occurs abundantly up to 700 ft. above sea level and sometimes above 1000 ft. (305 m.). The oft-repeated statement that there are no leguminous plants in Greenland is obviously erroneous, although the apparent absence of any species of *Astragalus* or *Oxytropis* is indeed remarkable.

## GERANIACEAE

[*Geranium Sylvaticum* Linn. — Not seen—cf. Porsild (1930, p. 18).]

## CALLITRICHACEAE

*Callitriche Verna* Linn. emend Lonnr.<sup>1</sup> — Evidently infrequent, though all too easily overlooked. Not seen by the Porsilds and by me found only once. This was at the new locality of Qag. in Tun. Fj. (no. 11031), where it grew with *Subularia aquatica* in shallow water and on wet mud around the margin of a pool behind Eric the Red's estate.

*Callitriche Hamulata* Kütz.<sup>1</sup> — Not rare. New localities: Sydprøven (no. 10237); Kingua in Tun. Fj. (no. 11070); bet. Ig. & Jul. (no. 11345). It seems that most of the Greenland material which has been determined as *C. anceps* Fernald belongs instead to the present species, although this is not the case with Jens Vahl's specimen from Tasermiut which has been so variously interpreted by Lange (1880, p. 14, as *C. verna* var. *latifolia* Kütz.: 1887, p. 238, as *C. polymorpha* Lönner.), Rosenvinge, Ostenfeld, and others—including Samuelsson (in Veröffentl. d. Geobot. Institut. Rübel, Zürich, III, p. 621: 1925) as *C. anceps*.

[*Callitriche Anceps* Fernald — Not seen—cf. above. It would seem that Professor Fernald (1925, p. 281) himself doubts the occurrence of this plant in Greenland.]

## VIOLACEAE

[*Viola Selkirkii* Pursh ex Goldie — Not seen.]

*Viola Palustris* Linn. — Common.

*Viola Ericetorum* 'Hayne', var. *Friesiana* Wilmott (*V. canina* Linn. [var.]  $\gamma$  *montana* Fries, not *V. montana* L.) — In proposing the above name, Mr Wilmott (in Journ. Bot.

<sup>1</sup> Apparently the author's own orthography—contrast Index Kewensis, I, p. 389.

LXXIX, pp. 205-6; 1941) draws attention to his neglected paper (Journ. Bot. LIV, pp. 257 et seq.; 1916) in which he shows that *V. montana* L. is *V. elatior* Fries, and that Solander's specimen labelled 'Alpes Lapponiae', which 'Linnaeus doubtless saw' and 'referred to in his *Species Plantarum*' (Wilmott in lit. and in Journ. Bot. LIV, p. 261; 1916), is also *V. elatior*. The present plant is fairly frequent in the region which I traversed, the following new localities being noted: bet. Agd. & Ig. Fjords (no. 10604); S. of Qag. in Tun. Fj. (no. 10951). On the favourably sheltered bank of a stream at Igaliko, where this plant and, I think,<sup>1</sup> the next species were growing together, I found a few examples of the apparent hybrid between the two (no. 11310). These supposed bastards seemed to be producing good seed, as some other *Viola* hybrids have long been known to do (cf. Brainerd in Rhodora, VI, p. 219; 1904), although more often in this genus hybridity is followed by a greater degree of sterility (Brainerd in Rhodora, VI, pp. 216 et seq., 1904, and VIII, pp. 50 et seq., 1906).

*VIOLA LABRADORICA* Schrank (? syn. *V. Muhlenbergiana* Ging.  $\beta$  *minor* Hook.) — Frequent, and a charming little plant. New localities: Lichtenau (no. 10451); bet. Agd. & Ig. Fjords (nos. 10496, 10636); S. of Qag. in Tun. Fj. (nos. 10936, 10952); Kingua in Tun. Fj. (no. 11037).

### ONAGRACEAE

*EPILOBIUM PALUSTRE* Linn. (aggr.) — This and the following three rather closely related species, although they are often locally quite plentiful near the outer coast, appear frequently to be absent or at least rare over considerable tracts of country around the heads of the larger fjords, where the climate is relatively dry and continental in type. The four species also appear to hybridize freely, the resulting offspring being probably often fertile (according to verbal information from Dr Tyge Bøcher, Copenhagen). Thus, while I would not dare so to determine them without further intensive study, I rather suspect that in the Julianehaab district there could be detected the hybrids *E. Hornemanni*  $\times$  *lactiflorum*, *E. Hornemanni*  $\times$  *anagallidifolium*, and *E. anagallidifolium*  $\times$  *lactiflorum*, while I am not at all sure about the 'purity' of some of my *E. palustre*. The following appear to be new localities for the last-named species: Qagsimiut (no. 10027); Sydprøven (nos. 10242, 10297); Qag. in Tun. Fj. (no. 11022). From Julianehaab, where it is common, it was early reported as '*E. lineare* Mühlenb.' by Lange (1880, p. 15 and cf. 1887, p. 239).

*EPILOBIUM ANAGALLIDIFOLIUM* Lam. (*E. alpinum* of authors, including Linn. in part—see Rendle & Britten in Journ. Bot. XLV, p. 438; 1907) — Fairly common at Julianehaab and elsewhere on or near the exposed sea-coast, including Josua-Minen, Kobbermine Bugt (no. 10011), but rare or wanting inland.

As to the employment of the name '*anagallidifolium*', although we have been warned that it is a mere 'relic of an outworn nomenclature', I prefer to persist in using it in the absence of conclusive demonstration that another should be used, and thus follow Professor G. Samuelsson in the latest of his publications to which I have access.

*EPILOBIUM LACTIFLORUM* Hausskn. — Not common, at least around the heads of the larger fjords. Additional locality: bet. Ig. & Jul. (no. 11318). No. 10310 from Sydprøven may quite likely represent the hybrid with *E. anagallidifolium*, which latter species has been found before at this place (cf. Rosenvinge, 1892, p. 659).

*EPILOBIUM HORNEMANNI* Reichenb. — New locality: bet. Ig. & Jul. (no. 11317). No. 10456 from Qagd. may possibly result from crossing with *E. anagallidifolium*.

<sup>1</sup> In any case *V. labradorica* has been recorded from Igaliko (cf. Rosenvinge, 1892, p. 668, sub nom. *V. Muhlenbergiana* Ging.  $\beta$  *minor* Hook.), and so has the present plant (cf. Porsild, 1930, p. 19, sub nom. *V. montana*).

*EPILOBIUM ANGUSTIFOLIUM* Linn. (*Chamaenerion angustifolium* (Linn.) Scop.) — Common. Very variable in luxuriance and leaf size and shape. Most of the plants fall within the limits of the rather doubtfully distinct northern var. *intermedium* of Fernald. This, however, is not the same as the original *Epilobium intermedium* Wormskj. 'floribus minoribus quam in forma typica' (Lange, 1880, p. 16, and cf. Polunin, 1940, p. 298), which I found once (no. 10947 from S. of Qag. in Tun. Fj.), and which appears to be at least a good variety: in my specimen the petals are 8 mm. long by at most 4 mm. wide in the expanded part.

*EPILOBIUM LATIFOLIUM* Linn. (*Chamaenerion latifolium* (Linn.) Sweet) — Fairly common. Varying markedly in size and luxuriance with differing habitat conditions, but the phases are not sufficiently constant to be satisfactorily separated in the present area (at least according to my material) into forms worth distinguishing.

### HALORAGIDACEAE

*MYRIOPHYLLUM ALTERNIFOLIUM* DC. — Quite common. Noted or collected in many places, including the following new localities: bet. Agd. & Ig. Fjords (nos. 10497, 10514, 10614, 10641); Gl. Qagss. (no. 10717); S. of Qag. in Tun. Fj. (no. 10922); Qag. in Tun. Fj. (not collected, but common); Kiagtut (no. 11196). The material appeared to vary, but Dr M. P. Porsild confirmed all the above determinations.

*HIPPURIS VULGARIS* Linn. — Common. My material includes some tiny, slender specimens only 1–7 cm. long from S. of Qag. in Tun. Fj. (no. 10965). However, like Devold & Scholander (1933, p. 48) on the east coast, I was unable to find any specimens belonging to the broad-leaved var. *maritima* (Hell.) Wahlenb.

### UMBELLIFERAE

*LIGUSTICUM SCOTICUM* Linn. (*Haloscias scoticum* (Linn.) Fries) — Not infrequent in sheltered spots near the shore. Additional localities: Qag. in Tun. Fj. (where, however, it may have been collected before, as Rosenvinge (1892, p. 681) remarks that it is common in this fjord); bet. Ig. & Jul. (not collected); ? Qagdl. (no. 10480a, seedlings only).

*ARCHANGELICA OFFICINALIS* Hoffm. (*Angelica Archangelica* Linn.) — Common, and very useful to both natives and hungry explorers.

### CORNACEAE

*CORNUS SUECICA* Linn. — Common, but not seen fruiting—cf. Rosenvinge (1892, p. 681), but contrast Devold & Scholander (1933, p. 56). No. 11319 from bet. Ig. & Jul. is a 'monstrous' form in which the shoots in the axils of the uppermost pair of leaves have grown out far beyond the flowers.

[*CORNUS CANADENSIS* Linn. — Not seen—cf. Porsild (1930, p. 19).]

### EMPETRACEAE

*EMPETRUM NIGRUM* Linn. var. *hermaphroditum* (Lange) Sørensen—cf. Polunin (1940, pp. 296–7). — Common. Like Porsild (1930, pp. 19–20), I was unable to find any red-fruited crowberries in SW. Greenland.

## PYROLACEAE

[PYROLA ROTUNDIFOLIA Linn. var. *arenaria* Mert. & Koch — Not seen—cf. Porsild (1930, p. 20).]

PYROLA GRANDIFLORA Rad. — Evidently rare. New locality: bet. Agd. & Ig. Fjords (no. 10536).

PYROLA MINOR Linn. — Common.

## ERICACEAE

LEDUM GROENLANDICUM Oeder — See Sprague (in Journ. Bot. LXXVII, p. 345: 1939). Common. It is doubtful whether *L. palustre* Linn. var. *decumbens* Ait., which is so plentiful to the north, enters our present area (cf. Rosenvinge, 1892, p. 692).

RHODODENDRON LAPPONICUM (Linn.) Wahlenb. — Common.

LOISELEURIA PROCUMBENS (Linn.) Desv. — Common. The leaves are said by the natives to form an important part of the food of Ptarmigan in both winter and summer, but this would seem to need confirmation; thus I have seen only an occasional leaf in crops that I have opened. In the area of East Greenland where Gelting ('Studies on the Food of the East Greenland Ptarmigan especially in its relation to vegetation and snow-cover', Medd. om Grønland, CXVI, no. 3, pp. 1-196; 1937) so carefully investigated the food of the local Ptarmigan, *Loiseleuria* is absent; in southern Norway where it is common (cf. Blytt, Norges Flora, p. 842; 1861), *Loiseleuria* forms only a very minor and irregular part of the Mountain Ptarmigan's food (cf. Lid, 'Om fjeldrypens næring', Norsk Jæger- og Fisker- Forenings Tidsskr., Medd. 56de Aargang, Oslo, 1927, table facing p. 162).

PHYLLODOCE COERULEA (Linn.) Bab. — Common.

CASSIOPE HYPNOIDES (Linn.) D. Don (*Harrimanella hypnoides* (Linn.) Coville) — Quite frequent in the uplands and also near the exposed sea-coast in spots where the snow lies longest (cf. Rosenvinge, 1892, p. 691). Collected at Kepisarko (no. 10002a), Sydprøven (nos. 10252, 10276), Akul. (no. 10404), hills above Gl. Qagss. (no. 10827), and Igaliiko (no. 11245); also seen several times in the course of a trek from the last-named place to Julianehaab.

[ANDROMEDA sp. — Not seen—see Porsild (1930, pp. 32 et seq.).]

OXYCOCCUS QUADRIPETALUS Gilib. var. *microphyllus* (Lange) Porsild (cf. 1930, pp. 38 et seq.) (*O. palustris* of Greenland authors) — Quite common. The leaves are variable in size and shape, being up to 4.5 mm. wide in some of my material, which accordingly does not all fall within the limits of the variety as given by Porsild (loc. cit.). Thus no. 10241 from Sydprøven has larger leaves than much of the material from Britain where the variety is unknown. Already in 1892 Rosenvinge observed (p. 692) 'Forma typica haud raro in locis fertilioribus invenitur, formis intermediis cum f. *microphylla* conjuncta'. But these larger leaves to be found in some Greenland material are broad and obtuse, not narrowish and acute as in British specimens.

VACCINIUM ULIGINOSUM Linn. — This occurs in two main form-series, each of which is abundant and variable chiefly in such 'minor' characters as hairiness and the shape and size of the leaves and fruits:

(i) var. *genuinum* Herd.—mostly f. *pubescens*;

(ii) var. *alpinum* Bigel. (subsp. *microphyllum* Lange)—sometimes glabrous (e.g. no. 11407 from Julianehaab) but more often hairy (f. *Langeanum* (Malte) Polunin). These two

main tendencies, the small (northern, diploid) and large-leaved (southern, tetraploid),<sup>1</sup> seem to represent different microspecies (cf. Hagerup in *Hereditas*, xviii, pp. 122 et seq.: 1933). Their 'hair' phases are of lesser taxonomic importance (cf. Polunin, 1940, p. 315). In the notable absence of any confirmatory specimens it seems probable that all reports of *Vaccinium Myrtilus* from the area have been founded on field observations of the present species growing, as it occasionally does, with upright shoots and upwardly directed leaves.

*VACCINIUM VITIS-IDAEA* Linn. var. *minor* Lodd. (var. *pumilum* Hornem.) — Evidently extremely local. Seen at Sletten in Agdluitsoq Fjord (not Igaliko Fjord as reported by Grøntved), where it was collected a few weeks later by the Dano-Norwegian expedition, who also report another new locality (leg. E. Mørch) near Julianhaab (see Grøntved, 1938, p. 254).

#### DIAPENSIACEAE

*DIAPENSIA LAPPONICA* Linn. — Not common; but not, I think, really rare. Plentiful specimens were collected at Qagsimiut (no. 10017a), Sydprøven (no. 10337), bet. Agd. & Ig. Fjords (no. 10516), and Igaliko (no. 11250). Beautiful flowering tufts were also encountered several times at medium altitudes on Akul.

#### PRIMULACEAE

[*PRIMULA STRICTA* Hornem. — Not seen—cf. Porsild (1930, p. 21).]

*PRIMULA EGALIKSENSIS* Wormskj. — Found again three times at Igaliko, where, however, it is far from plentiful; also at Gl. Qagss. (cf. Lange, 1887, p. 260) and Qag. in Tun. Fj. (no. 11102), which last appears to be a new locality. All flowering specimens had the white corolla of the typical form.

#### PLUMBAGINACEAE

*ARMERIA MARITIMA* (Miller) Willd. (sensu lat.) — In many places common near the sea-shore, and sometimes extending several kilometres inland. A white-flowered variant was found at Gl. Qagss. (no. 10740)—cf. Rosenvinge (1892, p. 683), who found such plants among normal ones at Igaliko. Rosenvinge also makes some useful observations about the dispositions of the various forms in this difficult group. Although it is variable in indumentum, my material is all referable to the above species (syn. *Statice maritima* Miller), the segregation of *A. labradorica* Wallr. (? and *A. sibirica* Turcz.) being still problematical. I am unable to discover any good *differentiae*, and, in the absence of a detailed revision of all the northern *Armerias* throughout their range, can only call the variable SW. Greenland plexus by the above inclusive name.

#### GENTIANACEAE

*GENTIANA NIVALIS* Linn. — Common. The white-flowered f. *albiflora* (Lange) Rosenvinge was collected on ten different occasions. Although usually occurring in far smaller numbers than the typical form, it was to be found almost everywhere that I went.

*GENTIANA AUREA* Linn. — Fairly common. Like Rosenvinge (1892, p. 689), I noted it at many points in Igaliko and Tunugdliafik Fjords, of which the following appear not to have been published: Igaliko (no. 10887); S. of Qag. in Tun. Fj. (no. 10909); Qag. in

<sup>1</sup> As has already been pointed out by Hagerup (in *Hereditas*, xviii, p. 128; 1933), this forms a useful exception to the generality that where polyploidy occurs it is the form most resistant to unfavourable conditions (e.g. the arctic one) which is polyploid—cf. also Flovik (in *Hereditas*, xxvi, pp. 437–8; 1940).



Tun. Fj. (no. 10993); Kingua in Tun. Fj. (indubitable material seen but only the doubtful no. 11050 collected). Varying markedly in luxuriance, occasional starved and stunted specimens being very reminiscent of *G. tenella* Rottb.—indeed I have seen specimens that have been so labelled, e.g. 'C. Kruuse ad Kakasuak pr. Kringarsuak 30 Juli 1902'.

*GENTIANA DETONSA* Rottb. (*G. serrata* Gunn.—see Porsild, 1935, pp. 43 et seq.) — Found again at Igaliko, and at the new locality of Qag. in Tun. Fj. (no. 11020). Also seen a few kilometres north of this latter place, but evidently local. Individual plants, especially when growing in competition with swarded grasses far above sea level, may be extraordinarily reduced and slender (e.g. my no. 10891 from Igaliko). This seems to be the explanation of some at least of the 'splits' which have been made in this group—cf. Porsild (1935, pp. 49–52).

*GENTIANA AMARELLA* Linn. (aggr.) — New to the flora of Greenland—unless a single large and apparently typical plant (17 cm. high) in Herb. Copenhagen, labelled '*Gentiana Amarella ex Groenlandia*', can be substantiated. At present it lacks locality, date, and even any collector's name; although it apparently goes back to about the time of Giesecke, no one (not even Lange) appears to have noticed it or at least taken it seriously!

Evidently rare, though found twice at Igaliko (nos. 11282, 11300). My specimens differ markedly from what I understand to be the typical form, having, for instance, both the flowers and upper cauline leaves much smaller than in material from Iceland and Scandinavia; indeed the whole plant is smaller and more slender. Nor are the two collections (which were growing several kilometres apart on marshy areas) quite alike. On the whole, in spite of the deep blue colour of the corollas, they seemed closest to var. *uliginosa* (Willd.) Wahlenb. (*Gentiana uliginosa* Willd.), as was kindly confirmed by Mr A. A. Bullock of Kew and further by Mr A. J. Wilmott's remark recently written on one of the sheets of no. 11282 as follows: 'These specimens appear to be *G. uliginosa* Willd., although rather stout for that microspecies'; to this, indeed, Mr H. W. Pugsley early informed me one collection (no. 11300) 'comes very near'. But the other is rather different and so, in view of the extreme variability of the species and the absence of a full recent revision, it was considered best to reserve judgment and label all the plants 'cf. var. *uliginosa*'. However, during his visit to Oxford in 1942 after the completion of this paper, Mr Pugsley and I came to doubt whether my plants could be at all closely connected with Willdenow's species, and to wonder whether they did not represent an undescribed entity or possibly '*G. Amarella* subsp. *lingulata* (C. A. Agardh) F. Aresch. var. *subarctica* Murbek'. I was unable to find anything quite like them in Iceland in 1938 and certainly they do not belong to the Icelandic series separated by Ostenfeld & Grøntved (Fl. Iceland and Faeroes, p. 111; 1934) as '*G. amarella* L. f. *subarctica* Murb.'

*LOMATOGONIUM ROTATUM* (Linn.) Fries ex Nyman (*Pleurogyne rotata* (Linn.) Griseb.) — Fairly common, at least locally around the heads of Igaliko and Tunugdliarfik Fjords. Additional localities: Qag. in Tun. Fj. (no. 11017); Kingua in Tun. Fj. (see below). As usual extremely variable in the shape of the leaves and in the size and form of the entire plant, so that two or three of the *formae* distinguished by Fernald (in *Rhodora*, **xxi**, p. 197; 1919) are frequently to be recognized in the same stand, though with doubtful advantage. The plants also vary in the colour of the flowers from quite dark blue to very pale (e.g. no. 11051 from Kingua in Tun. Fj.). The species appears to be confined to maritime situations but not, I think, to saline habitats.

A completely white-flowered form was found near the head of Tun. Fj. (no. 11042): f. *albiflorum* nov. forma. *Corolla tota alba*. Typus in Herb. Mus. Brit., co-typus in Herb. Fielding Univ. Oxon. I have seen similar plants in Iceland (cf. Ostenfeld & Grøntved, 1934, p. 112); but in distinguishing and naming such plants I feel guilty of conforming to past practice rather than happy to follow any present conviction of serving a useful purpose by so doing. The day may be not far distant when, starting with single-gene

mutations where the correlated character is strikingly evident, we shall take to naming the genes (e.g. by the characters they control) regardless of where they appear within a coenospecies and its subordinate entities.

*MENYANTHES TRIFOLIATA* Linn. — Not at all rare. New localities: S. of and around Qag, in Tun. Fj. (locally abundant and very luxuriant). Said to ripen fruit successfully in good summers. Preserved remains of its rhizomes are plentiful in the bogs at Qag, in Tun. Fj. to a depth of at least 120 cm. (the identification of my sub-fossil material was kindly confirmed by Prof. Knud Jessen of Copenhagen).

## LABIATAE

*THYMUS ARCTICUS* (Durand) Ronniger (*T. Serpyllum* Linn. var. *prostratus* Hornem.—see Porsild, 1935, pp. 35 et seq.) — Common. Apparently uniform in the district, throughout both lowlands and uplands, where it is to be found to nearly 1000 metres (e.g. on Akul.).

## SCROPHULARIACEAE

*LILOSELLA AQUATICA* Linn. — Evidently rare. Not seen by me, but found the same summer by Eilif Dahl at Julianchaab (cf. Grøntved, 1938, p. 253). Dahl has kindly sent me a specimen.

*VERONICA ALPINA* Linn. — Common (e.g. no. 10115 from Julianchaab, and nos. 10412 and 10427 b from Akul.), and in the present area generally quite distinct from the upright, coarse hairy var. *unalaschkensis* Cham. & Schlecht. (*Veronica Wormskjoldii* Roem. & Schult., *V. alpina* var. *villosa* Lange). This is also common in SW. Greenland (e.g. nos. 10116 and 10158 from Julianchaab, and no. 10368 from Akul.), where the two varieties are often to be seen actually growing together, both in the mountains and near sea level.

*VERONICA FRUTICANS* Jacq. (*V. saxatilis* Scop.) — Common. Sometimes attaining nearly 1000 metres in the mountains, where, already in 1892 (p. 685), Rosenvinge gave it as reaching 1700 ft.

*VERONICA SERPYLLIFOLIA* Linn. — Seen growing plentifully around the cryolite mines at Ivigtut, where it has evidently been introduced in recent years, and whence I was sent specimens which had set ripe seed by the middle of September in 1937. Also occurring 'at the Radio Station' at Julianchaab, according to Grøntved (1938, p. 254).

*EUPHRASIA ARCTICA* Lange apud Rostrup (*E. latifolia* Pursh, not Linn.: *E. frigida* Pugsley) — Common, and very variable: possibly not all the same species although Pugsley (in Journ. Bot. LXXI, p. 309; 1933) has remarked 'In Greenland only one species, *E. frigida*, can be recorded with certainty.' Of this one species Pugsley (op. cit.) records several 'groups' from various parts of Greenland. Concerning the value of these Dr E. O. Callen of Edinburgh appears sceptical, as he reports (in lit.), after a careful examination of specimens from all my Greenland *Euphrasia* collections, that with one exception they clearly belong to *E. arctica* (which he agrees is the valid name), although varying in their robustness and glandulosity. The abundance and proportion of glandular hairs and eglandular bristles is moreover very variable, as is also the outline of the leaves and the branching of the whole plant. The exception mentioned above was part of no. 10453 from Lichtenau, which Mr Wilmott and I had already separated as no. 10453a on account of its relative smoothness and small size; of it Dr Callen remarks (in lit.) that it 'is extremely interesting on account of its glandular foliage', so that it 'does not resemble any of the species known from Iceland'. Dr Callen goes on to suggest that it resembles most closely his own *E. Pennellii* (Callen in Journ. Bot. LXXVIII, p. 214; 1940) but 'might be worth describing as a new form'. However, careful examination under a binocular microscope

revealed similar glands, both stalked and sessile, on leaves of plants belonging to all my other collections; even the shining-white eglandular trichomes (whose relative paucity in no. 10453a Dr Callen mentioned in a subsequent letter as the chief *differentia*) are plentiful on the axes and on both surfaces of some of the lower leaves of no. 10453a, as in my other gatherings. Accordingly, in the absence of any other visible 'character', I can but retain no. 10453a within the admittedly variable *E. arctica*; indeed this seems the only sound course as the individuals comprising no. 10453a are all very immature and appear to have been starved by competition (they were growing clustered together in a dense mossy sward).

*BARTSIA ALPINA* Linn. — Common and often to be observed at considerable altitudes—cf. Rosenvinge (1892, p. 687).

*RHINANTHUS MINOR* Ehrh. (sensu lat.) — Common, and very variable. Although some of the specimens approach *R. groenlandicus* Chab., under which most recent authors have placed all Greenland material, none of them agrees entirely with the original account of that species, and some seem definitely nearer to *R. minor*, to which indeed the Greenland plants were referred by earlier authors. Mr A. J. Wilmott, who has recently revised the British material of *Rhinanthus* (cf. Wilmott in Journ. Bot. LXXVIII, pp. 201–13; 1940), and has given considerable attention to *R. groenlandicus* Chab., which had been reported from the British Isles, has kindly examined my material and makes the following remarks: 'The above specimens are placed under *R. minor* Ehrh. rather than *R. groenlandicus* Chab. because some of them correspond more with the description of the former than with the account given by Chabert of his *R. groenlandicus*, with which none of them agrees entirely. Whether these gatherings represent one or two species, and if two what are their constant distinctive characters, is a matter which requires critical study of the characters in the field, and further series of specimens. Only nos. 10462 (from Qagd.) and 11015 (from Qag. in Tun. Fj.) have the remarkable projecting leaf-teeth characterizing *R. groenlandicus* and distinct from those of any European *R. minor* Ehrh. I have seen. But of these two gatherings, no. 10462 alone has the great stature described by Chabert, no. 11015 reaching about 20 cm. only. No. 11015 has the large capsules of *R. groenlandicus*, but no. 10462 is in flower only. Neither is completely glabrous. The remaining specimens are smaller, being of the size of smallish *R. minor*: their capsules are not consistently larger than in *R. minor*. No. 10360, from Akul., has broad leaves with leaf-teeth projecting but less extreme than in nos. 10462 and 11015; they are probably only small specimens conspecific with the larger ones, but they are definitely pubescent. Three other gatherings are more like *R. minor* Ehrh., viz. nos. 10341d and 10448 from Lichtenau, and no. 11157 from Kiagtut.'

*RHINANTHUS BOREALIS* (Sterneck) E. S. Marshall — No. 10888 from Igaliko has the calyx puberulous all over its surface, but is unsatisfactory for certain determination. Mr Wilmott (in Bot. Soc. & Exch. Club Brit. Isles, Rep. for 1939–40, p. 372; 1942) has confirmed it as 'normal *R. borealis*'. *R. borealis* has already been reported from Greenland by Fernald (1925, p. 269) as well as by Sterneck (Monogr. d. Gatt. Alectorolophus, Wien, p. 113; 1901) who rather trustingly (on what appears to be material from only three districts) described it as a circumpolar type.

*PEDICULARIS FLAMMEA* Linn. — Not merely 'ikke sjelden' (Lange, 1880, p. 76), but decidedly frequent, as Rosenvinge remarked (1892, p. 686). This is especially the case away from the coasts and on the lower slopes of mountains. Collected on Akul. (no. 10360), bet. Agd. & Ig. Fjords (nos. 10506, 10537, 10537a), at Gl. Qagss. (no. 10652), Qag. in Tun. Fj. (no. 10978), Kiagtut (no. 11121), and bet. Ig. & Jul. (no. 11337). No. 10537a is a single plant, found growing alone, of a 'monstrous' or parasitized form with

the calyx lastingly hairy and fully two-thirds as long as the pod (instead of glabrate and only one-third to half as long as the pod).

Reports of *P. groenlandica* Retz. from our area appear all to be in error (cf. Rosenvinge, 1892, p. 686, and many later authors). It also seems doubtful whether *P. lapponica* Linn. occurs in our area, although it is common to the north (cf. Rosenvinge, loc. cit.).

### LENTIBULARIACEAE

*Pinguicula vulgaris* Linn. — Common.

*Utricularia minor* Linn. — Found only S. of Qag. in Tun. Fj. (no. 10968), which appears to be a new locality (cf. Porsild, 1935, p. 26). As usual sterile.

### PLANTAGINACEAE

*Plantago maritima* Linn. — Frequent. Varies markedly in size and luxuriance with local habitat conditions. Mr Wilmott and I were unable to refer my material to *P. juncoides* Lam. as opposed to *P. maritima* (see Fernald in Rhodora, xxvii, pp. 93 et seq.; 1925), as comparison with British material at Oxford showed that such characters as the shape of the bract, the length of the anthers, and the relative lengths of leaf and scape are too inconsistent to be employed as differentiae. So, too, are numerous other characters, as has recently been emphasized by Gregor (in New Phyt. xxxviii, pp. 294 et seq.; 1939), though it should be noted that whereas he observed 'four developed seeds as the typical number' per capsule in 'North American and Greenland samples' (as opposed to a 'typical maximum' of 'two viable seeds per capsule' in Europe), two and three appeared to be the most frequent numbers developed in my material from the Julianhaab district. As far also as the seed characters given by Devold & Scholander (1933, p. 92) could be tested in my material, the conformity appeared to be with the European *P. maritima*: mature seeds in no. 11314 from Igaliko were all at least 1.5 mm. long and sometimes approached 2 mm. The capsules of the Greenland specimens do appear to be in general shorter and more rounded at the apex than is usual in British material, but even in Britain their shape is variable, though usually elongated and tapering. We therefore preferred to place my specimens under *P. maritima* Linn. and leave the question of the specific distinction of the American material for future investigation—e.g. by following up the recently published observations of Gregor and his associates (loc. cit. and elsewhere in New Phyt.). The range of variation in my material may then be indicated by reference to the forms already distinguished in the area by Lange (1880, p. 69) and Rosenvinge (1892, p. 682). Even so, my gatherings are not uniformly referable to these forms, but tend to show variation similar to that met with in Britain. Specimens which can be reasonably referred to the forms enumerated (but not always so named) by Lange (loc. cit.) occurred as follows:

(i) var. *glauca* Hornem. (*Plantago borealis* Lange) — No. 10482 (rather variable) and probably no. 10458 (vegetative only), both from Qagd.; part of no. 10660 from Gl. Qagss.

(ii) Lange's ' $\alpha$ , foliis anguste linearibus, subcarnosis': this corresponds with Fernald's '*P. juncoides* var. *decipiens*', though what exactly it is to be called cannot be determined just now — No. 10659 (and, less typically, part of no. 10660) from Gl. Qagss.

(iii) Lange's ' $\beta$  *scorzonerifolia* (Lam.), foliis late linearibus, planis, integerrimis v. parce denticulatis, Fl. Dan. tab. 243!' — No. 10648 from Gl. Qagss., and perhaps some of the broader-leaved specimens in no. 11314 from Igaliko, most of which latter is referred by Mr Wilmott to 'var. *juncoides* (Lam.) Gray'.

### RUBIACEAE

*Galium brandegeei* A. Gray (*G. palustre* Linn.  $\beta$  *minus* Lange) — Not rare: collected at Qagd. (nos. 10462, 10479), Gl. Qagss. (no. 10769), and Qag. in Tun. Fj. (no. 10990); also seen elsewhere (collection data lost).

*GALIUM TRIFLORUM* Michx. — Quite common in favourable situations.

*GALIUM ULIGINOSUM* Linn. — Apparently only a recent introduction at Ivigtut, where it is plentiful and certainly thrives. Observations concerning this and some other species were later checked by Grøntved (cf. 1938, p. 253), and confirmed by specimens kindly sent to me at the British Museum by Eilif Dahl. The old reports that this species occurs in Greenland, e.g. by Hooker (in Trans. Linn. Soc. Lond. XXIII, p. 293; 1861), were long ago discounted by Lange (1880, p. 92).

### CAPRIFOLIACEAE

[*LINNAEA BOREALIS* Linn. var. *americana* (Forb.) Rehder — Not seen—see Porsild (1930, p. 22).]

### CAMPANULACEAE

*CAMPANULA UNIFLORA* Linn. — Evidently rare in the district. Not found by me, but collected twice during the same summer by the Dano-Norwegian Botanical Expedition (see Grøntved, 1938, p. 252).

*CAMPANULA ROTUNDIFOLIA* Linn. (aggr.) — Common. So extremely variable that even if the two main series (cf. Lange, 1887, p. 270) are cytologically quite distinct (cf. Bøcher in Hereditas, XXII, pp. 269 et seq.; 1936), the various minor forms are far too intricate to be separated at present on morphology alone. Moreover, as observed by Devold & Scholander (1933, p. 94) in south-east Greenland, 'All the varieties described seem to be united by intermediate forms' also in south-west Greenland. Both Lange's (1880, p. 93) var. *uniflora* 'pumila, caule adscendente, flore solitario, parvulo' and his var. *arctica* 'erectiuscula, pauci- v. uniflora, floribus magnis, speciosis' occur in white-flowered forms not uncommonly in the Julianhaab district, where indeed a quite extraordinary number of albinos are to be found not only among the Dicotyledons but also among the grasses (see above).

### COMPOSITAE

*ERIGERON COMPOSITUS* Pursh — Seen only in the collections of the Dano-Norwegian expedition made the same year at Kragtut? (I think; in any case it has already more than once been reported from Tun. Fj.), and certainly at 'Arsukfjord: eastern side of Kùgnait', from which place I have a scrap before me (leg. Dahl).

Although this genus is cited as neuter in the International Rules, ed. 3, it seems best to keep it masculine as (i) this has been the common practice of late and (ii) the last International Congress reduced the pertinent part of Art. 72 in the Rules to a recommendation that Greek or Latin generic adoptions should retain their classical gender instead of that assigned by their first botanical author.

*ERIGERON UNIFLORUS* Linn. emend. Vierh. — Quite scarce, as Porsild (1930, p. 23) remarks, or at least very local; thus, writing in 1892, Rosenvinge (p. 699) said 'Syd for 64° kun fundet paa Jensens Nunatak...og ved Igdlorsuit 61° 4''. New localities: Akul., where it was encountered many times at altitudes chiefly between 900 and 1100 m. (nos. 10343, 10394, 10426c); Lichtenau (no. 10431). This seems to be the true *E. uniflorus*, and I could find no sign of *E. unalaschkensis* or *E. eriocephalus*, with both of which it has often been confounded (cf. Polunin, 1940, pp. 343 et seq.).

*ERIGERON BOREALIS* (Vierh.) Simmons (*Trimorpha borealis* Vierh., *Erigeron alpinus* of northern authors, *E. neglectus* of some authors) — Common. Very variable, some specimens being difficult to distinguish from phases of the last species—e.g. nos. 10035 from Julianhaab, 10508 from bet. Agd. & ÿg. Fjords, and 11294 from Igaliko. Cf. also Devold & Scholander (1933, p. 96) who state that 'The line of demarcation between

*Erigeron borealis* and *Erigeron uniflorus* in East Greenland is very indefinite so that the classification of the numerous transition forms is always a case of subjective judgment'.

**ANTENNARIA GROENLANDICA** Persild — So frequent that I collected it no less than 14 times. The specimens show considerable variation in the shape of the leaves and phyllaries and even in the exertion of the style at maturity; but none of the phases seems separable taxonomically even if the species is apomictic! The plants tend to be smaller than in south-east Greenland, being generally only 8–12 cm. high and rarely reaching 15 cm.; nor have I seen as many as half the 21 capitula to an axis described in one instance by Devold & Scholander (1933, p. 95).

**ANTENNARIA AFFINIS** Fernald — Apparently new to SW. Greenland—see Persild (in Rhodora, xxxiii, p. 215; 1931) and Fernald (in Rhodora, xxxiii, p. 222; 1931), and cf. Grøntved (1938, p. 252). Found at Qag. in Tun. Fj. (no. 10972) and Kiagtut (nos. 11136, 11137, 11173), in which latter place it was also collected the same year by Grøntved (loc. cit.). My determinations were kindly confirmed by Dr M. P. Persild. The plants grew in patches on dry sandy soil clothed chiefly with lichens; the maximum height reached by my specimens, too, is only 10 cm. (cf. Grøntved, loc. cit.).

**ANTENNARIA CANESCENS** (Lange) Malte (*A. alpina* of authors) — Locally fairly frequent. Found at Sydproven (no. 10334), Akul. (nos. 10344 b, 10397, 10418, 10419), bet. Ig. & Jul. (nos. 11333, 11341, 11347). The material is not without variation and seems to require further study, especially to elucidate its connection with the next species.

**ANTENNARIA COMPACTA** Malte — New to the flora of Greenland. For range, etc., of this little-known species see Polunin (1940, pp. 352–3). In 1937 found in full development only on Akul. (no. 10344 c), but less typical specimens doubtfully referable to this species were collected in alpine situations (i) bet. Agd. & Ig. Fjords (no. 10527) and (ii) around Gl. Qagss. (nos. 10656, 10703, 10746).

In 1930 (p. 23) Persild tentatively reported '*Antennaria* ? *intermedia* (Rosenvinge) Persild . . . not typical, perhaps another species', but I have neither seen his specimen nor in any other way been able to determine which of the above species, if any, was meant. A specimen collected on Kùgnait, Arsukfjord, by Dahl and tentatively determined as *A. intermedia* (with the added observation '*atypica*') lies before me. It certainly does not conform with my conception of the form-series of any of the above species, but is too immature and incomplete to identify definitely.

**ANTENNARIA PORSILDII** E. Ekman — New to the district, and evidently rare. Found only once, high up on Akul. (no. 10420).

The *Antennarias* reported from our area by earlier authors (especially Lange and Rosenvinge) are probably all to be referred to one or another of the above; consequently a revision of the old collections may lead to a revision of some of my 'new' localities.

**GNAPHALIUM SUPINUM** Linn. — Fairly common.

**GNAPHALIUM NORVEGICUM** Gunn. — Common.

**GNAPHALIUM ULIGINOSUM** Linn. — Seen only at Ivigtut, where it appears to be a mere recent introduction.

**ACHILLEA MILLEFOLIUM** Linn. (aggr.) — Not common, though not particularly rare. Mostly the var. *nigrescens* E. Meyer, which was found some kilometres inland of Gl. Qagss. (no. 10705), and subsequently at Qag. in Tun. Fj. (no. 11010), where the flowers were noted as 'sometimes pale lilac', and finally at Kiagtut (no. 11158). At Kingua in Tun. Fj. were found plants (no. 11033) which appeared to approach the typical form

rather closely; others, in a purely vegetative condition, which seemed to belong to this category rather than to var. *nigrescens* occurred near Qagssiarssuk in the same fjord (no. 11090). The species has often been found before in both Igaliko and Tunugdliarfik Fjords (Lange, 1880, p. 102; Rosenvinge, 1892, p. 700).

*MATRICARIA INODORA* Linn. var. *nana* (Hook.) Torrey & Gray emend. Polunin (var. *phaeocephala* Rupr.; var. *grandiflora* (Hook.) Britton, not Poir.) — Collected at the following localities, sometimes in spots that are rarely if ever frequented by man nowadays: Sydprøven (no. 10237a); S. of Qag. in Tun. Fj. (no. 10907); Qag. in Tun. Fj. (nos. 11013, 11083). Also seen at Sletten in Agdluitsoq Fjord where it was probably introduced; these last specimens belonged, I think, to the typical form which has previously been found at Ivigtut and Julianehaab (Lange, 1887, p. 277). Eilif Dahl sent me a specimen of the typical form (*vide* A. J. Wilmott) which he had collected at Ivigtut in 1937 and determined as *M. Chamomilla*.

*CIRSIIUM HETEROPHYLLUM* (Linn.) Hill — Collected the same summer near Ivigtut by Grøntved (1938, p. 253). Probably a mere recent introduction.

*LEONTODON AUTUMNALE* Linn. — Locally plentiful in most places where it occurs, at least around Igaliko and Tunugdliarfik Fjords. Individual stations include: S. of Qag. in Tun. Fj. (no. 10912), and some few kilometres north of the same Qagssiarssuk (not collected); also Kingua in Tun. Fj. (not collected), all of which appear to be new. Unlike those in the next two genera, the variations in *Leontodon* in SW. Greenland appear to be confined to minor characters, the resulting forms being mere 'ecological' phases or, at most, ecotypes—cf. Turcason in *Hereditas*, vi, p. 177; 1925. Several of these forms can be studied in comfort at Julianehaab, where numerous individuals occur.

*TARAXACUM GROENLANDICUM* Dahlst. (*T. ceratophorum* of authors, *T. brachyceras* of Greenland authors) — Apparently common. According to his latest notes and re-determinations, Dahlstedt evidently considered that his *T. brachyceras* was absent from SW. Greenland, changing the name on all material therefrom to *T. groenlandicum*; this name I accordingly apply to all of my material that falls within its morphological range. The following appear to be fresh localities: Qag. in Tun. Fj. (nos. 10971, 11000, 11003, 11005); Igaliko (no. 11297); bet. Ig. & Jul. (no. 11338).

*TARAXACUM LAPPONICUM* Kihlm. (*T. croceum* Dahlstedt—see Polunin, 1940, p. 372) — Evidently quite common, as suggested by Porsild (1930, p. 23). New localities include Josua-Minen (no. 10008), Julianehaab (no. 10041), Sydprøven (not collected), Igaliko (not collected), and Akul. (no. 10342 pars), where it ascends to nearly 1000 m.

*TARAXACUM* cf. *ISLANDICIFORME* Dahlst. — Collections from Sydprøven (nos. 10205, 10247), bet. Agd. & Ig. Fjords (no. 10588), and Qag. in Tun. Fj. (nos. 11004, 11084, 11087) all compare well with others from the same region determined by Dahlstedt. No. 10042 from Julianehaab is much more doubtful. For Dahlstedt, Porsild reported (1930, p. 23) the 'new species' *T. leptoceras*, *T. pseudonaevosum*, and *T. maurostylum*. I cannot say what value, if any, these may have; but for a number of reasons I believe it is not great.

*HIERACIUM ALPINUM* Linn. — Common. Sometimes ascending to 1200 m. on the mountains.

*HIERACIUM LIVIDORUBENS* 'Almquist' (*H. nigrescens* Willd. subsp. *lividorubens* Almquist; *H. murorum* of some authors, incl. Lange, 1880, p. 96, etc.—acc. to Zahn in Engl. Pflanzenreich, iv, 280, Compositae-Hieracium, p. 688, 1921) — Apparently quite frequent. This and the next microspecies are not at all easily segregable, at least in the

Julianehaab district, as is evidenced by the number of mixed collections which I made and by the fact that apparent intermediates occur rather frequently. Accordingly in dealing with these species I was relieved to have the assistance of Mr H. W. Pugsley during a visit to me before the completion of his long-awaited revision of the British *Hieracia*; for his distinguished advice I was particularly grateful in view of the fact that all *Hieracia* of the *nigrescens* and allied groups belonging to the Copenhagen Herbarium were away on loan during my last visit there (the representation of the genus from Greenland in British herbaria was too meagre to be of any assistance). According to Zahn (in loc. cit.) the present plant is '*H. lividorubens* Almq. . . pedicellis densiuscule pilosa et disperse minuteque glandulosa (pilis apice longe albidis valde flexuosis haud tenuibus haud perspicuis, basi atris), squamis  $\pm$  atris anguste lanceolatis. . . [p. 689] Subsp. 1. *lividorubens* Almq. Grönland bis 300 m. . . Labrador! Ähnlich in Jemtland'. Mr Pugsley and I found the hair characters and degree of glandulosity to vary considerably even on the 'pedicels' of different capitula of apparently similar age on the same plant, but considered the following of my specimens to be referable here: Julianhaab (nos. 10094a, 10162 pars); Lichtenau (no. 10441); Akul. (nos. 10358 pars, 10359 pars); bet. Agd. & Ig. Fjords (nos. ? 10493 some of 'pedicels' unusually glandular, 10626 pars); Gl. Qagss. (nos. 10665 pars, 10796); Igaliko (no. 11282 pars); Kiagtut (no. 11119a); bet. Ig. & Jul. (nos. 11322 pars, 11339 incl. specimens reminiscent of *H. groenlandicum* q.v.). There appear to be previous reports from Julianhaab (Dahlstedt in Rosenvinge, 1892, p. 695, and Rosenvinge, 1896, p. 69), Igaliko (Lange, 1887, p. 271, and Dahlstedt, loc. cit.), and Kiagtut (Lange, 1880, p. 96, and Dahlstedt, loc. cit.), as well as several from Ivigtut, Arsuk and other places around.

*HIERACIUM HYPARCTICUM* (Almquist) 'Dahlst.' (*H. nigrescens* Willd. subsp. *hyparcticum* Almquist; *H. murorum* Linn. subsp. *hyparcticum* Lange; *H. atratum* of some authors, incl. Lange, 1880, p. 96—acc. to Zahn in tom. cit., p. 687) — Evidently common, but cf. the last species. Zahn (loc. cit.), who places it as a subspecies under *H. atratum* Fr., characterizes it as 'pedicellis dense longeque nigroglandulosa. . . squamis lanceolatis' and gives the distribution as 'Gronland [locis numerosis]. . . Ähnlich in Norwegen. . . und in Schottland'. This refers to the typical form, and after determining what we thought it must be Mr Pugsley and I found that I had gathered it plentifully on more than twenty different occasions, and, actually, at almost all the localities which I visited late enough in the season to find these slow-flowering *Hieracia* out; in view of which it would seem superfluous to list 'new' localities.

*HIERACIUM GROENLANDICUM* Arvet-Touvet (*H. dorrense* of some authors, incl. Lange, 1880, p. 97—cf. Zahn in tom. cit., p. 839; *H. dorrense* Fr. var. *groenlandicum* (A.-T.) Almquist) — Apparently less frequent than the last two, and usually quite distinct from them. Under *H. plicatum* Lbg., Zahn (loc. cit.) characterizes the typical form of his 'Subsp. 1. *groenlandicum* (A.-T.) Zahn' as (p. 840) 'Capitula. . . dense pilosa (pilis crispis apice albis sublongis) modice micro- et macroglandulosa. . . squamis late lanceolatis' and gives the distribution as 'Südgrönland, 60° 8'–64° 10' . . . Labrador', although according to Rosenvinge (1896, p. 69) it persists northwards to 'Tiggak i N. Strømfjord 67° 32''. Plants which, although they show marked variation, Mr Wilmott and I take to belong here, I gathered at the following 'additional' localities: Sydprøven (no. 10320); Akul. (no. 10358 pars); bet. Agd. & Ig. Fjords (no. 10565); Igaliko (no. 11282 pars); bet. Ig. & Jul. (no. 11339).

Porsild (1930, p. 24) reported from near the area which I visited *H. 'groenlandicum* subsp. *silvaticiforme* Dahlst. ad int.', although his specimen was 'very imperfect', and, on the same page, a tentative '*Hieracium* ? *amitsokense* Almq.' from Qag. in Tun. Fj. These and other reports and related problems require further study; I, too, have the impression that there may well be more species represented in my collections from this region than I have yet managed to separate at all satisfactorily.



*HIERACIUM RIGOROSUM* (Laest.) 'Almquist' (*H. auratum* of some authors, incl. Lange, 1880, p. 97—acc. to Zahn in Engl. Pflanzenreich, iv, 280, Compositae-Hieracium, p. 907, 1922; *H. prenanthoides* Vill. subsp. *rigorosum* (Laest.) Alm.; *H. strictum* Fr. subsp. *rigorosum* (Laest.) Alm. ex Dt.) — Quite common in favourable, sheltered situations. Collected fifteen times and seen on many further occasions—almost throughout the area traversed (except on the exposed sea-coast), so it seems unnecessary to list 'new' localities. By rhizomatous extension it may cover areas many metres in extent with aggressive colonies reminiscent of those of a Jerusalem artichoke. The plants vary, but apparently without consistency, in luxuriance and hairiness; 'Var.  $\beta$  *arctobium* Zahn.—*H. strictum* Lange...*H. auratum* Fr....ex Lange...*H. prenanthoides* Fl. Dan....Robustius subglaberrimum...involucris crassioribus' has been reported from Julianehaab by Zahn (in op. cit., p. 907).

The Greenland forms of *Taraxacum* and *Hieracium* are in need of thorough revision. With our war-time conditions and segregation from the Continent (particularly from the Botanical Museum of Copenhagen) it has been impossible to accomplish this or even to identify all forms with certainty. I have, moreover, not always been able to determine which plants were reported under the various names used by earlier authors (particularly Lange, and Dahlstedt in Rosenvinge); consequently some names have been omitted and the reports of 'new' localities are liable to need revision. Much the same is true of *Antennaria* (see above), and, as explained in the introduction, of a few grasses and members of the *Bigelowii-salina* group of Carices.

Additional species evidently of recent introduction which were seen (and generally collected) by me in 1937, or of which I was kindly sent specimens gathered the same year by Eilif Dahl of Oslo, are as follows: all were growing well and apparently attaining to vegetative maturity, while the vast majority were flowering and fruiting successfully in August and September. More detailed accounts of the majority of the species and repetitions of earlier reports will be found in Dr M. P. Porsild's most useful 'Alien Plants and Apophytes of Greenland' (Meddelelser om Grønland, xcv, 1932); some, however, do not appear to have been recorded previously from Greenland.

*AGROSTIS SCABRA* Willd. (see Fernald, 1933, p. 207 et seq.) — Julianehaab (no. 11428).

*DESCHAMPSIA CAESPITOSA* (Linn.) P. de Beauv. — Julianehaab. Long known from Ivigtut—see Rosenvinge (1892, p. 730) sub nom. *Aira caespitosa*.

*PHLEUM PRATENSE* Linn. — Sletten<sup>1</sup> and Ivigtut. Cf. Rosenvinge (1892, p. 727).

*POA PALUSTRIS* Linn. — Sletten (no. 10374).

*FESTUCA OVINA* Linn. — Sletten (no. 10372).

*AVENA SATIVA* Linn. — Ivigtut. Cf. Rosenvinge (1892, p. 731).

*LOLIUM PERENNE* Linn. — Julianehaab.

*RANUNCULUS REPENS* Linn. — Julianehaab.

*POLYGONUM CONVULVULUS* Linn. — Ivigtut. Cf. Lange (1887, pp. 277–8) and Rosenvinge (1892, pp. 701–3), who also report (or repeat previous reports of) *Polygonum lapathifolium* Linn., *P. Persicaria* Linn., *Rumex obtusifolius* Linn., and *Chenopodium album* Linn., as all growing introduced at Ivigtut. Lange (1880, p. 107) reports *Chenopodium glaucum* (sub nom. *Blitum*) and Rosenvinge (1892, p. 703) *C. album*, both from Julianehaab.

<sup>1</sup> See footnote 2 on p. 350.

*BARBAREA STRICTA* Andr. — Ivigtut.

*URTICA URENS* Linn. — Ivigtut. Cf. Lange (1880, p. 107).

*CARUM CARVI* Linn. — Julianehaab. Rosenvinge (1892, p. 682) reports this from Ivigtut and Frederiksdal, and adds (p. 684) '*Anagallis arvensis* L.  $\beta$ , *coerulea* Schreb.' as 'Introducta. Ivigtut, paa en Gaardplads'.

*TRIFOLIUM REPENS* Linn. — Julianehaab. Already reported by Lange in 1887 (p. 233) with three other Leguminosae as at 'Ivigtut, indførte og forvildede paa Gaardspladser...'.<sup>1</sup>

*TRIFOLIUM PRATENSE* Linn. — Ivigtut.

*MELILOTUS ALTISSIMA* Thuill. — Ivigtut.

*MYOSOTIS ARVENSIS* Lam. — Ivigtut.

*LAMIUM MOLUCCCELLIFOLIUM* Fries — Ivigtut. '*Anchusa arvensis* M. Bieb...' and '*Lamium purpureum* L. et *L. amplexicaule* L. in hortis ad Ivigtut' are so mentioned by Lange (1887, p. 264).

*PLANTAGO MAJOR* Linn. — Ivigtut. Cf. Lange (1887, p. 259).

*ARTEMISIA VULGARIS* Linn. — Ivigtut. Cf. Lange (1887, p. 274), who on this page mentions three other escaped Compositae as having been observed by Berlin (cf. 1884) at the same place.

*CHRYSANTHEMUM LEUCANTHEMUM* Linn. — Ivigtut.

*SENECIO VULGARIS* Linn. — Ivigtut. Cf. Lange (1887, p. 277).

*MATRICARIA SUAVEOLENS* (Pursh) Buchenau — Ivigtut.

Other plants, including some possible additions among those introduced, are reported from various parts of the area by Miss I. W. Hutchison on pp. 383-6 of her book 'On Greenland's closed Shore', published in 1930. But as a considerable proportion of the names employed are incomplete or doubtful, and as I have not been able to see her specimens, I have thought it wise not to quote her above. But worthy of note are Miss Hutchison's records (in op. cit. and in Journ. Roy. Hort. Soc. LVII, p. 25; 1932) of the beautiful *Mertensia maritima* growing on the sand at Sermersok Island, near Nanortalik, about which there can scarcely be a mistake, and her photograph (in Journ. Roy. Hort. Soc. LVII, fig. 27) of *Matricaria inodora* var. *grandiflora* in profusion on ruins at Igaliko.

<sup>1</sup> Lange also reports (1887, p. 240) *Erodium cicutarium* as 'in hortis ad Ivigtut introductum et hodie spontaneum...' and (1887, pp. 245 and 253) '*Spergula arvensis* L. in hortis ad Ivigtut observavit Berlin', and '*Chelidonium majus* L. Ivigtut, forvildet (Berl.)'; also *Verbascum Thapsus* Linn. (1887, p. 261), *Galium Aparine* Linn. (1887, p. 269), *Sonchus oleraceus* Linn. (1887, p. 271), *Anthemis arvensis* Linn. (1887, p. 276), and *Cannabis sativa* Linn. (1887, p. 278) all from the same place, and *Xanthium Strumarium* Linn. (1880, p. 104) from Lichtenau. Other additions to the ruderal flora of Ivigtut (not including purely 'garden' plants) are made by Hartz (1894, pp. 17-18), Porsild (cf. 1932), and Grøntved (1938, pp. 252-4).

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1939 Cambridge University Expedition to Jamaica.—Part I. A study of the botanical processes concerned in the development of the Jamaican shore-line. By V. J. CHAPMAN, PH.D., F.L.S.

(With Plates 16-20 and 23 figures in the text.)

[Read 28 October 1943]

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## I. INTRODUCTION, CLIMATE AND TIDES

In the summer of 1939 an expedition left Cambridge University with the primary object of studying shore-line development in and around Jamaica. The members of this expedition were as follows: Dr V. J. Chapman, shore-line botanist and leader; Dr H. Hamshaw Thomas, botanist in charge of the forest party; Mr J. A. Steers, geomorphologist and in charge of the schooner party; Mr W. R. Philipson, from the British Museum; Mr J. S. Colman, senior zoologist; Mr K. R. Sporne, junior botanist with the forest party; Mr J. Lofthouse, surveyor; Mr D. J. Crisp, junior zoologist. We were also fortunate in co-opting three scientists in Jamaica. These additional members were Mr C. E. Hamshire, a geographer, Miss O. Baxter and Miss L. Scudamore, botanists.

The expedition was primarily rendered practicable by the generous support of the Royal Society, to which body our thanks are due. Additional financial support was also forthcoming from a number of other sources. Mr Steers made a generous personal contribution, whilst money also came from the Royal Geographical Society; Gonville and Caius College, Cambridge<sup>1</sup>; St Catharine's College, Cambridge; New College, Oxford; the Worts Fund, Cambridge; the Balfour Fund, through the kindness of Prof. J. Gray, F.R.S.; the Challenger Society; the University of Manchester; the University of Sheffield; and the British Museum trustees who contributed towards the expenses of Mr Philipson.

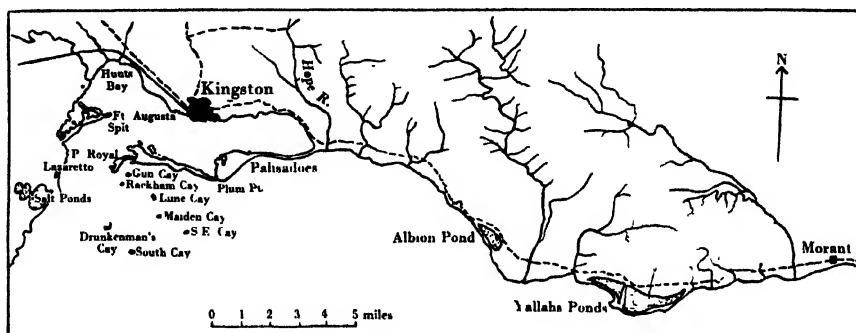
Apart from a financial contribution the Royal Geographical Society lent us the portable tide-gauge used by the Great Barrier Reef Expedition of 1928 and a theodolite, whilst some zoological equipment was very kindly lent by Lord Moyne. The British Museum provided and packed most of the zoological apparatus together with some of the botanical; the remainder of the equipment was provided by the Departments of Botany and Geography at Cambridge.

My wife undertook the onerous duty of financial secretary, thus relieving me from much office work and enabling me to carry out a considerable volume of field work. She was also responsible for the provisioning of the schooner for the two trips, and she arranged the supplies for the forest party. Mr B. O. Parks of Jamaica played a very large part in any success the expedition may have had. He acted throughout as our local agent and made all the arrangements in advance, thus enabling us literally to start work the day after we arrived. The Banana Producers Steamship Company not only allowed the expedition reduced rates but also took our fifty-four packing cases freight free.

<sup>1</sup> This College has also contributed towards the cost of publication.

In Jamaica the expedition as a whole and as individuals met with assistance from all quarters. The government of Jamaica provided us with every facility. Space was found for us in the laboratory of the government botanist and also in the School of Agriculture, whilst drying ovens were available in the laboratory of the agricultural chemist.

Valuable help and information was given by the Surveyor-General, the Director of Public Works, the Kingston Harbour Master, the Superintendent of the Hope Gardens, the Director of Agriculture, and the head of the School of Agriculture. Major Miller, the military commander of Port Royal, gave us every assistance in the establishment of the tide-gauge and arranged for a man to attend it. Mr Sherlock and Mr Lewis of the Institute of Jamaica not only gave us help with old records but also found storage space for part of our collections during the war. To all these and others who helped our thanks are due.



TEXT-FIG. 1. The coast-line of Jamaica around Kingston and to the east.

A Caymanian schooner of 80 tons, Capt. T. V. Ritch with Capt. T. Ritch as navigator, was engaged to take the party to the outlying cays and to Montego Bay. For work nearer the mainland a launch was employed, whilst for the ecological work in Hunts Bay use was made of a small boat with an outboard engine. A planter's house, Chestervale, was rented as headquarters for the forest party, and although some distance from the forest, nevertheless it was extremely convenient. One of the most valuable assets of the expedition was a motor car hired on generous terms to the party by General Motors Ltd. of Kingston.

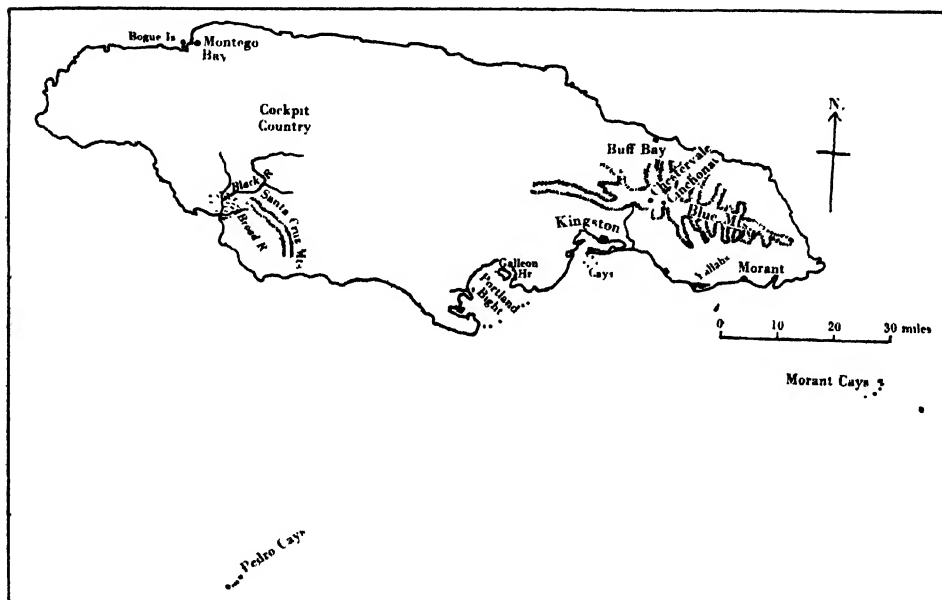
The primary object of the expedition was a detailed study of the physiographical, botanical and zoological processes that are associated in the development of the West Indian shore-line. The presence of ponds, e.g. the Lazaretto Pond and the Salt ponds opposite Port Royal, Albion Pond, Yallahs Pond<sup>1</sup> (cf. text-fig. 1), enclosed by narrow beaches suggested that a study of the spits might prove extremely profitable. Reef structure and development of the cays also form an integral part of the picture, and so it was proposed that the cays and reefs around Port Royal and in Portland Bight should be studied intensively, together with the two outlying groups, the Morant and Pedro cays (text-fig. 2).

I, as leader, Mr Steers, Mr Colman, Mr Lofthouse, Mr Crisp and Mr Hamshire constituted the party concerned in this investigation. Mr Philipson of the British Museum was sent out in order to gather material for the completion of Fawcett and Rendle's *Flora of Jamaica*<sup>2</sup>. Dr Thomas wished to study the ferns in relation to the phylogeny of certain groups, whilst Mr Sporne was collecting material in connexion with an investigation of flower morphology. These three, together with Miss Baxter and Miss Scudamore, formed the forest party.

<sup>1</sup> Spelt Yallahs on the Pomery map (cp. note p. 439).

<sup>2</sup> Species terminology in these papers is based on this *Flora*.

Mr Colman and I arrived in Jamaica on 22 July, 1939, whilst the remainder of the party, with the exception of Dr Thomas, arrived in Kingston on the 29th. Between 22 and 29 July, Mr Colman and I visited Gun Cay, Lime Cay, Albion Pond and the two Yallahs ponds east of Kingston. A visit was also paid to the Lazaretto Pond and to the mangroves in Hunts Bay (cf. text-fig. 1). As soon as the main party arrived the tide-gauge was established at Port Royal and the schooner party left for the Morant cays. Two days were spent on North-east Cay and one day each on Middle Cay and South-west Cay. At the end of the fourth day a heavy swell developed and as landing was becoming more and more difficult and the schooner had no auxiliary power, it was decided to return to Jamaica, leaving one cay unvisited, because a storm was suspected in the vicinity. After two days' rest and reprovisioning the schooner left under the charge of Mr Steers for the Pedro cays. Weather conditions were again adverse and two attempts to get there failed; so the schooner returned to Portland Bight and the numerous cays



TEXT-FIG. 2. Outline map of Jamaica showing the principal localities visited by the Expedition.

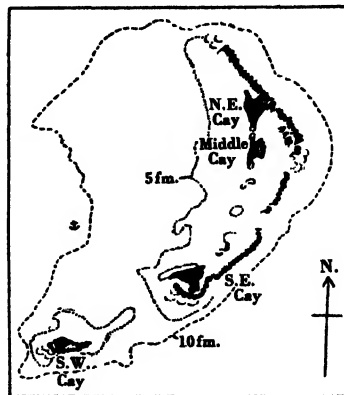
in that region were thoroughly investigated. The schooner then sailed to Montego Bay in order that the reef and Bogue Islands could be examined (text-fig. 2). Afterwards she returned along the north coast and the trip was terminated by an examination of the Port Royal cays. During this time Mr Hamshere was working on the physiography of the Fort Augusta spit and I had begun the ecological studies on the mangroves, whilst Philipson and Sporne were collecting in the area around Kingston. With the arrival of Dr Thomas on 11 August, the forest party went up to Chestervale and they were still there when war broke out. When the schooner returned attention was paid by everyone to the problems offered by the Palisadoes, whilst Colman, Crisp and I also revisited the Port Royal cays.

As a result of the outbreak of war the main party had to pack and leave four days earlier than was originally planned. In spite of the premature departure, practically the whole of the programme was completed. The principal botanical and zoological collections are stored at the Institute of Jamaica for the duration of the war, and this means that a number of reports will be unduly delayed in their publication.



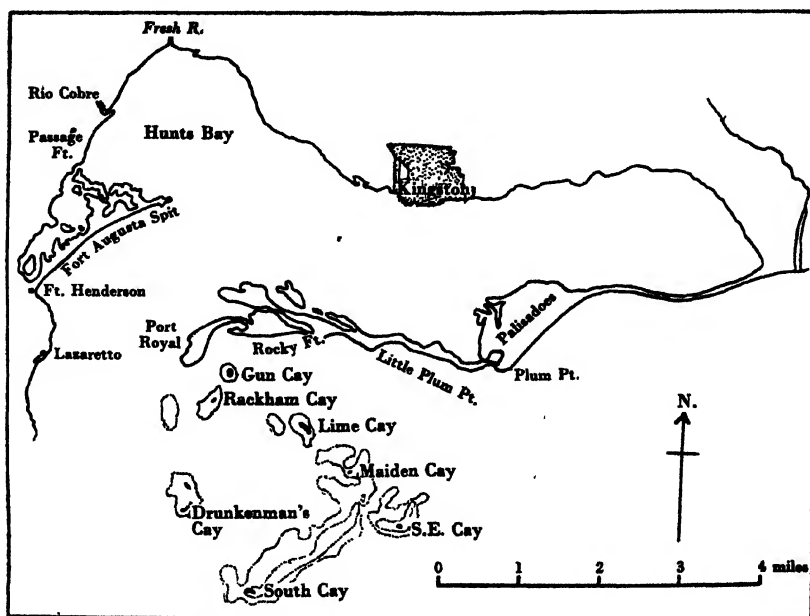
### Regional areas

1. *Morant cays* (text-fig. 3). The *West Indies Pilot* records three cays (actually there are four) which lie 30 miles south-east of Morant Point on a bank that extends for a distance of about 12 miles in a south-westerly direction. The general depths over the bank are from 10 to 18 fathoms, but in the centre it shoals to depths of less than 5 fathoms; it is on the east and south-east sides of this shoal that the cays are situated. North-east Cay varies from 5 to 7 ft. high and was divided into two unequal portions; it is recorded that at times it may become united to Middle Cay. South-east Cay lies nearly 1 mile south of Middle Cay; it is about 8 ft. high, and although the *West Indies Pilot* states that it is covered with bushes, nevertheless none was found. Sand-spits, which extend from the end of the cay, vary in shape at different seasons of the year. South-west Cay, which we did not visit, lies about 1 mile farther to the south-west and is 10 ft. high. These cays all have a large bird population and men visit them annually in order to collect the eggs.



TEXT-FIG. 3. A map of the Morant cays.

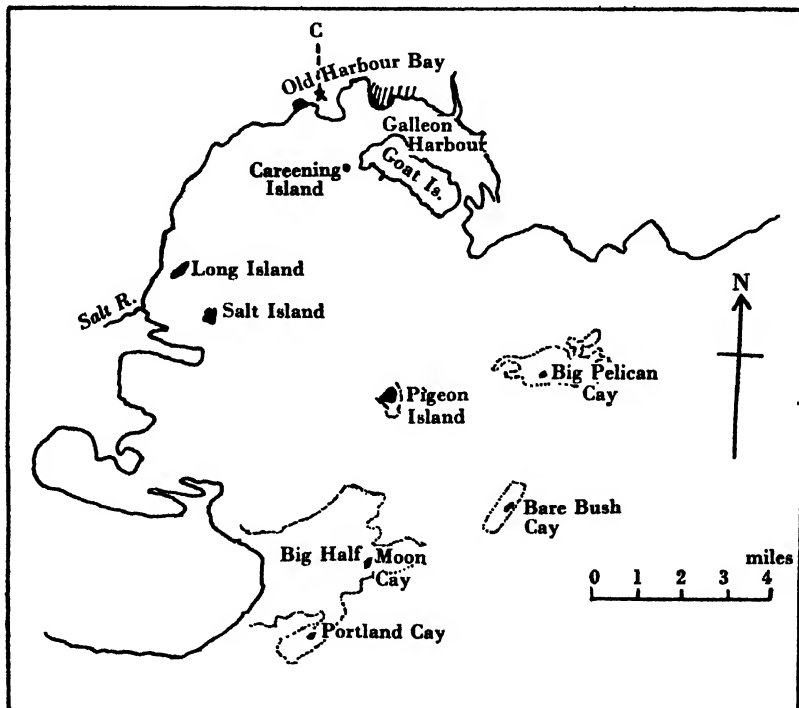
2. *Port Royal cays* (text-fig. 4). Gun Cay, which is situated on a small isolated reef of its own, lies nearest to the distal end of the Palisadoes and it bears a scrub vegetation,



TEXT-FIG. 4. A map of Kingston Harbour and the cays off Port Royal.

some of the trees reaching a height of about 40 ft. Rackham (Rackum) Cay is about  $3\frac{1}{2}$  cables south-south-west of Gun Cay, but as it is only just awash at high water it bears no land vegetation. Lime Cay, which is the largest of this group, is covered with

bushes and low trees. It is situated on the eastern edge of a shoal that slopes off gradually to the south and north-west but which dips sharply on the east to 18 fathoms. Maiden Cay is a very small low sandy cay lying  $6\frac{1}{2}$ – $8\frac{1}{2}$  cables south-east of Lime Cay. The *West Indies Pilot* records bushes on this cay but there was none in 1939. South-east Cay, which is the outermost cay on the southern side, lies about  $2\frac{1}{4}$  miles south-west of Plumb or Plum (as on the Pomeroy Map) Point on the Palisadoes and about 9 cables south-east of Maiden Cay. It is heavily wooded with mangroves. South Cay lies at the south-western end of a long narrow reef, which extends in a north-easterly direction almost to South-east Cay, and is covered by low bushes and tall mangroves. One and a half



TEXT-FIG. 5. A map of the cays in Portland Bight.

cables north-west of South Cay is South Rock, whilst the last of this group is Drunkenman's Cay. This lies about 11 cables north-north-west of South Rock and has a partially enclosed lagoon on the north side. It is heavily wooded with mangroves on the south side, the trees reaching a height of 30–40 ft.

The whole of the southern side of Kingston harbour is formed by the 8 miles long sandy spit known as the Palisadoes (Plate 18) which leaves the mainland near the mouth of the Hope River. On the seaward side it is covered with sand-dunes of varying height, whilst on the protected north shore there are extensive mangrove swamps, especially around Plumb Point and Rocky Fort. Immediately opposite Port Royal is the Lazaretto (quarantine station) with the small Red Water Pond, which is cut off from the sea by a narrow sand-spit (Plate 16, fig. 4). The north-east part of the pond passes into salina, whilst at the southern end it is bordered by mangroves. The Fort Augusta spit leaves the mainland at Port Henderson about 1 mile north-west of the Lazaretto; and runs in a north-easterly direction for nearly  $2\frac{1}{4}$  miles. For most of its length it is covered by low

sand-dunes with mangroves on the northern shore with the ruins of Fort Augusta at the distal end. This spit forms the south-east boundary of Dawkins Pond, a body of water which is surrounded by dense mangrove swamps that extend unbroken in a northerly direction up to the principal mouth of the Rio Cobre at Passage Fort. In the hinterland these swamps give way to a salina. Beyond Passage Fort the shore of Hunts Bay is broken by the other mouths of the Rio Cobre and then by the Fresh River, whilst there are also numerous minor creeks.

3. *Cays of Portland Bight* (text-fig. 5 and Plate 16, fig. 3). The Pelican reefs lie  $2\frac{3}{4}$ – $3\frac{1}{2}$  miles from the north-east shore at the entrance to the Bight. They bear Big and Little Pelican cays, both of which are covered with grass, cacti and mangroves. Pigeon Island, which lies about  $1\frac{1}{2}$  miles westward of the west end of the Pelican reefs, contains a shallow lagoon and some salt-pans. Natives engaged in the salt industry live on the island at various times. In the centre of the entrance to Portland Bight there is a short narrow reef bearing Bare Bush Cay. The Portland reefs commence about  $1\frac{1}{2}$  miles south-west of this reef and extend thence right up to the south-west shore of the Bight. Big and Little Half-Moon cays lie on these reefs about  $2\frac{1}{4}$  and 2 miles respectively west-south-west of the south-western end of Bare Bush reef. Portland Cay lies about 2 miles south-west of Big Half-Moon Cay. Goat Island, enclosing Galleon Harbour, is not a cay but an island of rock rising to an elevation of some 335 ft. Off its north-western extremity there is the small densely wooded Careening Cay with more reefs on its western side. At the mouth of the Salt River, which empties into the western shore of the Bight, is Salt Island.

4. *Montego Bay* (text-fig. 2). Montego Bay is situated on the north coast of Jamaica not far from the extreme western end of the island. The Bogue Islands, which are low sand shoals covered with mangroves, lie on the south-western side of the bay.

### *Climate*

The barometric pressure rises and falls twice daily with great regularity, standing highest in the morning and late evening and lowest in the afternoon and early morning. The prevailing winds during most of the year are the continuation of the north-east trade winds of the Atlantic. Around Kingston harbour, the large land mass of the Blue Mountains brings about local northerly winds in winter, but over the Morant cays the wind remains more or less uniformly easterly. There is also a diurnal variation in the wind around Jamaica though not at the Morant cays. During the night a land breeze comes down off the mountains and continues to blow until shortly after sunrise, attaining its maximum velocity about 1 a.m. The trade wind comes in from the sea about 10 a.m. and continues to blow until about 5 p.m. when it ceases. The strongest winds occur in June and July, and they attain to a very considerable force in the neighbourhood of Port Royal. Hurricanes are a feature of considerable significance in these regions, because such winds must have a very marked effect upon the structure and shape of the low-lying sand cays. Hurricanes are most prevalent between August and October, but they have been recorded in every month (cf. Table I).

TABLE I. *Recorded hurricanes in the West Indies during the last 300 years*

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	7	11	6	5	10	42	96	80	69	17	5

By permission of the Controller of H.M. Stationery Office.

The most frequented path of hurricanes in the northern half of the Carribean Sea extends due east and west between the Windward Islands and Jamaica.

TABLE II (from *West Indies Pilot*)

**Authorities:** MS. data supplied by Jamaica Weather Service, Kingston. Meteorological Office, Air Ministry.  
**Place:** Kingston, Jamaica. Lat. 17° 58' N., long. 76° 48' W. Height above mean sea-level, 110 ft. Meteorological tables compiled from 10 to 59 years' observations.

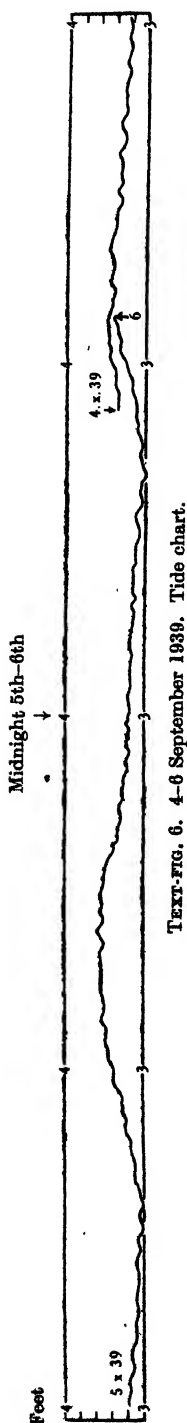
Month	Pressure at mean at sea-level, reduced to 32° F. and lat. 45°		Air temperature						Relative humidity	Cloud amount scale 0-10	Rain		Wind										No. of days' gales	No. of days' fogs																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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Hours of observation 07.00 and 15.00.  
 \* ‡ (07.00—15.00 + max. + min.).

† Day with 0.01 in. or more rain.  
 ‡ Maximum fall during the 24 hr. from one morning observation to the next.

§ Velocity of 35 knots or over.  
 ¶ Mean of highest each year and lowest each year.

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The average temperature varies considerably, depending upon altitude. At Kingston it ranges between  $76^{\circ}$  and  $81^{\circ}$  F., but at Chestervale the values are much lower and descend to about  $55^{\circ}$  F. The hottest months are June to September, and during this period the thermometer may reach  $90$ – $97^{\circ}$  F. Records made by a thermograph on the shore at Hunts Bay showed that the daily temperature there was highest at about 3 p.m. and reached its minimum about 6 a.m. just before sunrise. So far as the shore plants are concerned maximum transpiration will take place between 9 a.m. and 5 p.m., but there will be a period between 7 p.m. and 7 a.m. when the excessive water loss of the daytime can be made good.

The relative humidity sank to a minimum value between 8 and 10 a.m., and although there is a strong diurnal variation, ranging from 60 to 85 %, there is little or no seasonal fluctuation. The rainfall varies considerably from place to place, especially in the Blue Mountains, and there is a marked contrast between the northern slopes, with an annual precipitation of over 100 in., and the southern slopes with only 60–70 in. At Kingston the annual rainfall is as low as 30 in. Unfortunately, no data are available for the Morant cays, but it is to be expected that the precipitation there would be even lower. The rainfall has two maxima, May–June and September–October, with a well-marked break in July. North of the Blue Mountains, however, there are extensive winter rains between November and January, whilst on the southern slopes August may also be rainy.

#### The tides

The principal feature of the tides is their extremely small range, and this is a phenomenon which must constantly be remembered when considering the problems associated with land development and the intertidal conditions under which the plants and animals exist. Another feature of these tides is the fact that they are sometimes diurnal, i.e. there is only one high tide each day (cf. text-fig. 6, where high water on 4 September occurred at 13.30 hr. and the next high water was on 5 September at 15.00 hr.). At Port Royal the mean range of the tide is given as 0.7 ft. and the spring range as 0.9 ft. From the appearance of the drift line, however, it is evident that under storm conditions the maximum range is slightly over 1 ft.

## 2. STRAND AND DUNE VEGETATION

The principal communities which have been described by previous workers are: (1) the *Coccoloba-Hippomane* community, (2) the *Pes-caprae*<sup>1</sup> community, (3) the *Tournefortia* community. Börgesen (1909) and Raunkaier (1934) regarded these communities as formations, whilst Schimper (1936) and Rübel (1930) considered that they were associations<sup>2</sup>. The use of the terms 'association' and 'formation' implies that the vegetation forms part of the climax for that region. Around Kingston the strand and dune vegetation merge into each other so that it is almost impossible to distinguish them. Börgesen (1909) mentions that real dunes are rare in the Danish West Indies because the sand is too coarse-grained for the wind to move it readily. On the spits and beaches near Kingston the sand is primarily mineral

<sup>1</sup> *Ipomoea Pes-caprae*.

<sup>2</sup> Also Beard (1944).

in nature and is subject to wind influence, so that quite considerable dunes are formed (Plates 17, 19). On the cays wind and sea together build up low dunes even though the material is coarse-grained, so that we may quite properly speak of a dune vegetation. If the vegetation of the strand and dunes is in a state of equilibrium then we must regard it as the climax vegetation and call it the Dune-Strand formation of the Caribbean. This might well involve a number of parallel seres all terminating in the same climax community. If this view were adopted then the *Coccoloba* and *Pes-caprae* communities would respectively become an association and a consociation. In any case it would seem clear that they hardly warrant the status of 'formation'.

The usual definition of the term 'association' implies that there is more than one dominant, whereas in the consociation there is only one dominant. The names given to two of these communities by previous workers indicate that there is only one dominant, and that therefore they ought logically to have been called consociations. It would, however, be very difficult in Jamaica to say that *Coccoloba uvifera*, *Hippomane Manicella*, or *Ipomoea Pes-caprae* were the sole dominants in the first two communities, and it would be more satisfactory to regard both as associations. The *Tournefortia* community described by Börgesen (1909) from the Danish West Indies was not evident around Kingston. The species associated with *Tournefortia gnaphalodes* in St Croix, *Borrchia arborescens*, *Scaevola Plumieri*, *Suriana maritima*, *Ernodea litoralis*, *Bontia daphnoides*, *Dodonaea viscosa*, *Dalbergia Ecastophyllum*, were not abundant on the dunes and cays visited.

We have still to consider whether the vegetation is in a state of equilibrium or whether developmental changes may not be taking place. Several plant communities can be recognized in the vegetation of the cays and the Palisadoes, and they appear to be associated in some respect with what is known or suspected from the age of the area. In other words, there is evidence suggesting that the communities form part of a developmental sere, leading to an edaphic climax. This edaphic climax may be termed the Dune-Strand formation of the Caribbean. In different areas the same type of community may be part of the climax or part of a sere depending on the degree of physiographic stability in the region. Generally the *Coccoloba-Acacia-Conocarpus* community on the strand will have the status of an association, whilst the *Sesuvium-Sporobolus-Ipomoea* community will usually have the status of an associes.

Börgesen and Raunkiaer both refer to an independent *Conocarpus* formation or community, but there was no clear evidence of any such around Kingston or on the cays, although many of the associated species were to be found. When present it is intermediate in position between the mangrove and the dune vegetation and would be difficult to assign to either. Börgesen originally referred it to the mangrove vegetation (1909), but subsequently placed it in the Dune-Strand flora. He reported that the soil on which it grew was nearly always old lagoon substratum, but there was no evidence of such a community at the Lazaretto or at the Yallahs ponds. Around Kingston *Conocarpus* always grew on slightly raised dune behind the other mangrove vegetation.

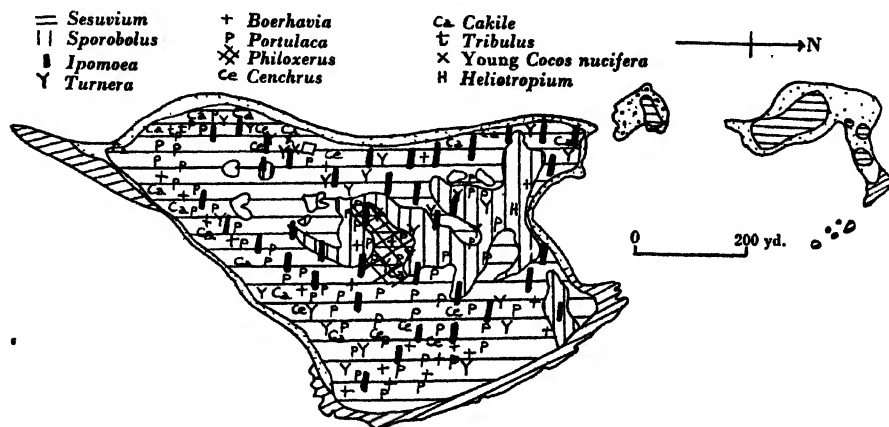
Studies of maritime dunes in Great Britain (Salisbury, 1925; Oliver & Salisbury, 1913) have shown that there is a definite succession in the vegetation with increasing age or height of the dune, and that the following stages can be recognized: (a) embryo dune, (b) yellow dune, (c) grey dune. In Europe the embryo dune originates as a collection of sand around one or two isolated plants and hence it is not very stable. In the yellow-dune phase a number of embryo dunes unite, there is more vegetation and the phanerogams and mosses stabilize the sand through the binding action of their roots and rhizoids, but there are still considerable areas of bare sand exposed to wind attack. In the grey-dune stage the vegetation covering is complete and stabilization has been secured, not only through the binding action of the roots but also by the completeness of the plant cover. The plants which carry out this process are primarily herbs, e.g. *Psamma arenaria*, *Carex arenaria*, *Festuca rubra*, *Elymus arenarius*, *Eryngium mari-*

*timum*, *Arenaria peploides*, etc.; bushes and trees are rare, although *Hippophæ rhamnoides* may be abundant in some districts. Pines will grow on such dunes, but they are usually planted and do not arrive naturally. The vegetation, therefore, is responsible for the stability of the dunes, and hence of the coast-line, through the *direct* action of the plants in binding the sand.

It remains to be seen whether the Caribbean dune plants behave in a similar manner. Before taking up this point, it is proposed to describe in some detail the vegetation, not only in order to provide a picture of its various facies but so that future workers on the same areas may have information which will enable them to note such changes as take place over recorded periods of time.

### Morant cays (Plates 16, 17)

All the Morant cays were covered with plants of the *Sesuvium-Sporobolus-Ipomoea* associes, the first two commonly being the dominants. In August 1939, North-east Cay was composed of one large islet and two smaller islets on the north-east extremity. On



TEXT-FIG. 7. Vegetation map of North-east Cay, Morant.

both these latter there were only patches of *Sesuvium Portulacastrum*. On the main islet the huts used by the egg collectors were about half-way along the east shore and nearby were two planted coconuts. From the huts to the southern extremity and from thence along the north-west shore to the 'promenade',<sup>1</sup> plants of *Cakile lanceolata* occupied an area just above high-water mark but slightly below the level of the remainder of the vegetation. *Sesuvium Portulacastrum* and *Sporobolus virginicus* rarely occurred together and there was usually a well-marked line of demarcation between the two species (Plate 16, fig. 5). The large irregular area occupied by *Sporobolus* in the centre and northern part of the main cay can be seen in the vegetation map (text-fig. 7). Plants of *Ipomoea Pes-caprae* trailed over the *Sesuvium*, especially along the western shore and in the region adjoining the promenade, although the conditions in the latter locality could hardly be described as favourable.

In the centre of the cay and around the huts were numerous plants of *Turnera ulmifolia*, the flowers of which opened in the evening and early morning. In the centre of the cay there was also abundant *Philoxerus vermicularis*, which is evidently much appreciated by the birds as it was severely eaten down whereas the neighbouring *Sesuvium* was barely touched. Spreading from the centre out towards the promenade

<sup>1</sup> For a full account of this structure see Steers (1940).

and then extending down the ridge on the east to the southern extremity were scattered plants of *Portulaca oleracea*. In addition to these conspicuous elements in the flora the following species also occurred: *Heliotropium curassavicum* (one plant only), *Cenchrus echinatus*, *Boerhavia scandens*, *Tribulus cistoides*, *Tournefortia gnaphalodes* and *Cyperus ligularis*.

There was a number of depressions in the dunes on this cay. These were either bare or else covered by standing water, but even in the former the water-table was very close to the surface.

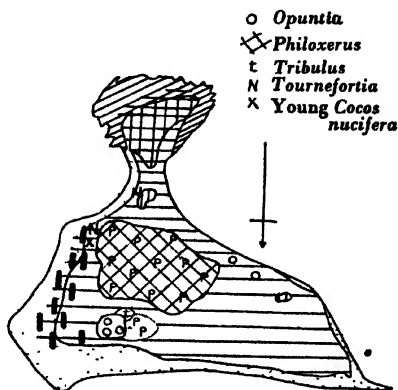
The high water-table and the consequent lack of aeration is probably responsible for the absence of vegetation in the depressions, although it will be seen that in other localities such places are occupied by *Batis maritima*. The small tidal range effectively prevents the water-table from sinking more than a few inches. These depressions were about 0.5 ft. below mean sea-level, and observations of the water-table in pits showed that there was a small fluctuation in the level, corresponding probably to the tidal movements. A longer visit would have been necessary in order to determine whether these movements exhibited a lag on the tidal movements comparable to similar lags described by Hill & Hanley (1914) for Blakeney dunes and by the present author for Scott dunes (1937).

Middle Cay bore a vegetation that was fundamentally the same, and again it was very evident that the dominant species rarely intermingled. There was a distinct patch of *Sporobolus virginicus* near the promenade (map, text-fig. 9), whilst the centre of the cay was occupied by *Philoxerus vermicularis*, which had suffered much from the depredations of the birds. The remainder of the cay was covered with *Sesuvium Portulacastrum*, although there was a small patch of *Boerhavia scandens* near the centre. Occasional plants of *Ipomoea Pes-caprae* straggled over the *Sesuvium*. *Cakile lanceolata* grew along the northern strand and also occurred in the hollows between dune ridges. Other species recorded from this cay were: *Turnera ulmifolia*, *Tournefortia gnaphalodes* and *Paspalum vaginatum*.

South-east Cay was interesting on account of a large patch of *Opuntia Tuna* near the huts and two small patches on the eastern side. Nearly the whole of the cay was occupied by a pure stand of *Sesuvium Portulacastrum*, but in the centre there was an area with a mixed vegetation of *Philoxerus vermicularis* and *Portulaca oleracea* (text-fig. 8). The latter species also occurred round the huts, as did a patch of *Tribulus cistoides*. There were two small patches of *Sporobolus virginicus*, and near the promenade this grass was mixed with *Sesuvium*. The only other additional species were *Tournefortia gnaphalodes* and a young *Cocos nucifera* which was probably planted. Neither this nor Middle Cay contained any bare depressions similar to those found on North-east Cay.

The principal interest of this islet lies in the presence of the *Opuntia*, because I believe that it represents the beginning of the second phase of the dune succession.<sup>1</sup>

In a personal communication, Mr Lewis of the Institute of Jamaica informs me that he believes the vegetation of these cays has been materially affected by the egg collecting, and that it is therefore to some extent artificial. It is possible that the present vegetation has developed after some interference, but there is no doubt that the community to be found there to-day, even though it may be of a secondary character, does represent an

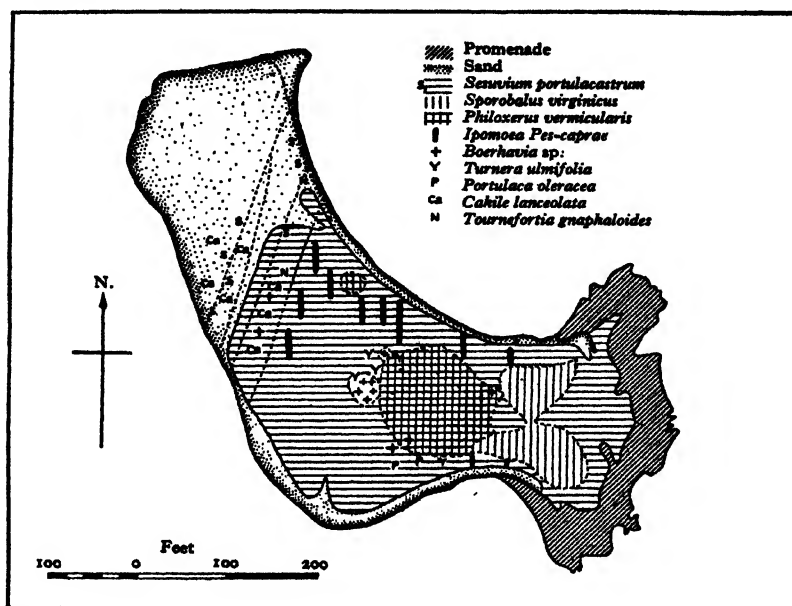


TEXT-FIG. 8. Vegetation map of South-east Cay, Morant, on the same scale as text-fig. 9 and with the same symbols.

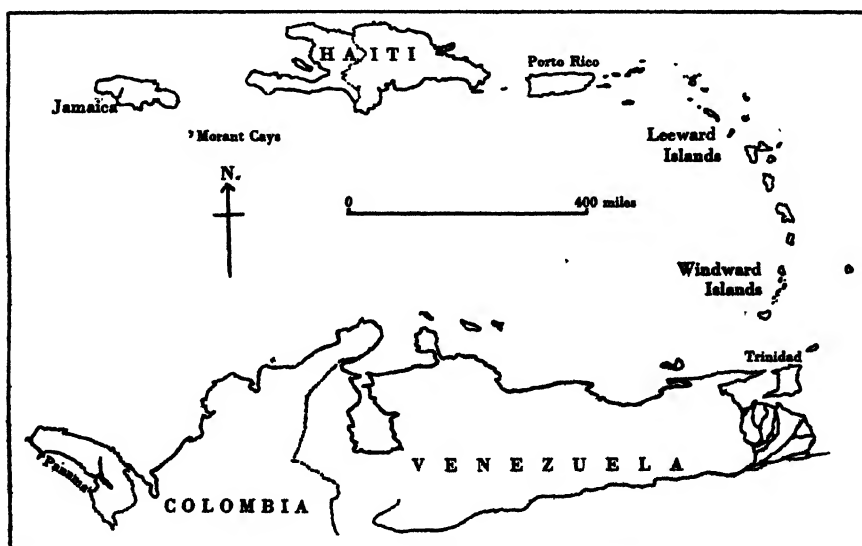
<sup>1</sup> The vegetation map of this cay was made in haste due to deteriorating weather and is therefore not so accurate as that of the other two cays.



early stage in the colonization of dune and strand which is extremely characteristic of the Caribbean region as a whole. One interesting feature was the complete absence of *Batis maritima* on the Morant cays that we visited; at present there does not appear to



TEXT-FIG. 9. Vegetation map of Middle Cay, Morant (from the *Geographical Journal*).



TEXT-FIG. 10. A map of the Caribbean showing the position of the Morant cays in relation to the mainland and to other islands.

be any adequate explanation, because the conditions would seem to be extremely favourable for the growth of this species.

Finally, we must consider whether there is an adequate explanation for the absence of mangroves on the Morant cays. In the introduction it was noted that the prevailing winds of this region blow from the south-east and east, although they may become more northerly in winter. Mangroves are distributed primarily through the seeds and seedlings which float in sea water, and since they float on the surface their course is more likely to be determined by the prevailing winds than by the currents, although in some areas the latter may be of significance. It will be seen (text-fig. 10) that the prevailing winds directly impede the drift of seeds or seedlings from Jamaica towards these cays. Under these conditions any floating material must reach them from the south-east or east, and inspection of the map (text-fig. 10) indicates that the nearest land is 300 (Haiti) or a 1000 miles (Windward Isles) away. Although there is evidence that mangrove seedlings can float sufficient time to travel these distances, the chances that they would strike four small islets in a relatively large area of ocean are small. The islets, moreover, cannot be regarded as stable. If it be granted, however, that both these conditions be fulfilled, there yet remains the fact that any seedlings would arrive on the steep-to side of the reef where the waves are very rough. Here, if they were not battered to pieces, seedlings would be thrown up on the rocky promenade which faces this side and their chances of further survival would be negligible. I believe that all these circumstances have combined to prevent mangroves from appearing on these cays, especially since Mr Lewis informs me that he knows of no previous record.

#### *Port Royal cays* (Plate 17, figs. 8, 11 and Plate 20, fig. 22)

The dominant feature of these cays as compared with those of the Morant group is the occurrence of mangroves. Apart from the mangroves there are open sandy areas covered by the typical *Sesuvium-Sporobolus-Ipomoea* associates. In no place was there any evidence of the *Conocarpus* and *Coccoloba* communities.

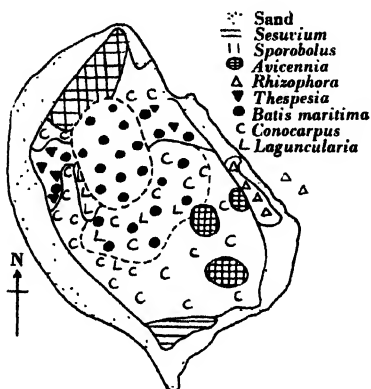
The northern portion of Gun Cay (text-fig. 11) bore a vegetation that approached nearest to a *Conocarpus* association with a mixture of *Conocarpus erecta* and *Thespesia populnea*; *Sporobolus virginicus*, *Tribulus cistoides* and *Batis maritima* formed the ground vegetation with an unidentified climber (Leguminosae) scrambling over the lower branches of the trees.<sup>1</sup> In the centre of the cay there was a shallow depression with standing water and a carpet of *Batis maritima*. This species appears to tolerate highly saline habitats and can withstand long periods of waterlogging. Raunkiaer (1934) refers to the occurrence of *Batis* in shallow depressions or on low flats, and its presence here and on the salina behind Dawkins Pond is typical of the species. The southern part of Gun Cay was occupied by a thick growth of *Laguncularia racemosa* with *Batis* forming the ground flora in many parts. On the western side there was a small *Rhizophora* patch and a few isolated *Avicennia* trees behind. The southern tip was composed of a low sandy area covered by pure *Sesuvium Portulacastrum*.

Lime Cay, which is the largest of the group and hence probably the most stable, bore over much of its area a vegetation more advanced than the *Sesuvium-Sporobolus-Ipomoea* associates. There was a scrub of *Acacia* sp. with *Thespesia populnea*, *Conocarpus erecta* and *Opuntia Tuna*. The ground vegetation was more varied and contained, in addition to the ubiquitous dominants, the following species: *Euphorbia buxifolia*, *Heliotropium curassavicum*, *Batis maritima* and *Tribulus cistoides*, together with others. Lime Cay was certainly covered with a vegetation to which a parallel could be found on the Palisadoes. Interesting features of this cay were the two ponds occupied by *Rhizophora Mangle*, though the one along the eastern shore had an additional outer fringe of *Avicennia nitida* (cf. p. 435).

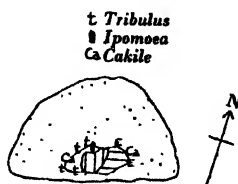
<sup>1</sup> We expected to revisit these cays had it not been for the war, and the number of recorded species would no doubt have been further increased.

Maiden Cay (text-fig. 12) possessed a vegetation which contained the following species: *Sporobolus virginicus*, *Sesuvium Portulacastrum*, *Ipomoea Pes-caprae*, *Euphorbia buxifolia* and *Tribulus cistoides*. One or two plants of *Cakile lanceolata* occurred somewhat lower down on the beach.

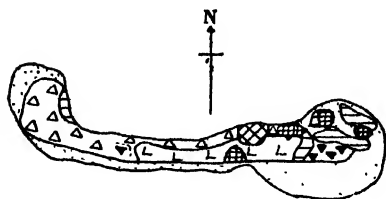
South-east Cay (text-fig. 14), with its peculiar rampart, was primarily covered by a scrub of *Laguncularia racemosa* with a narrow fringe of pure *Sesuvium Portulacastrum* on the south and a wider fringe on the west. Near the landing on the north shore there was a grove of *Rhizophora Mangle*: this was succeeded by a few large trees of *Avicennia nitida*, and behind there were some openings where a ground flora of *Batis maritima* and *Philoxerus vermicularis* existed. There were a few scattered bushes of *Conocarpus erecta* on this cay and also another *Rhizophora* patch near the small bay on the south shore.



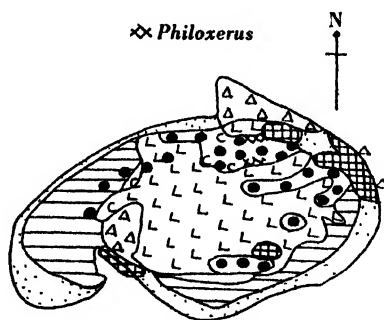
TEXT-FIG. 11.



TEXT-FIG. 12.



TEXT-FIG. 13.



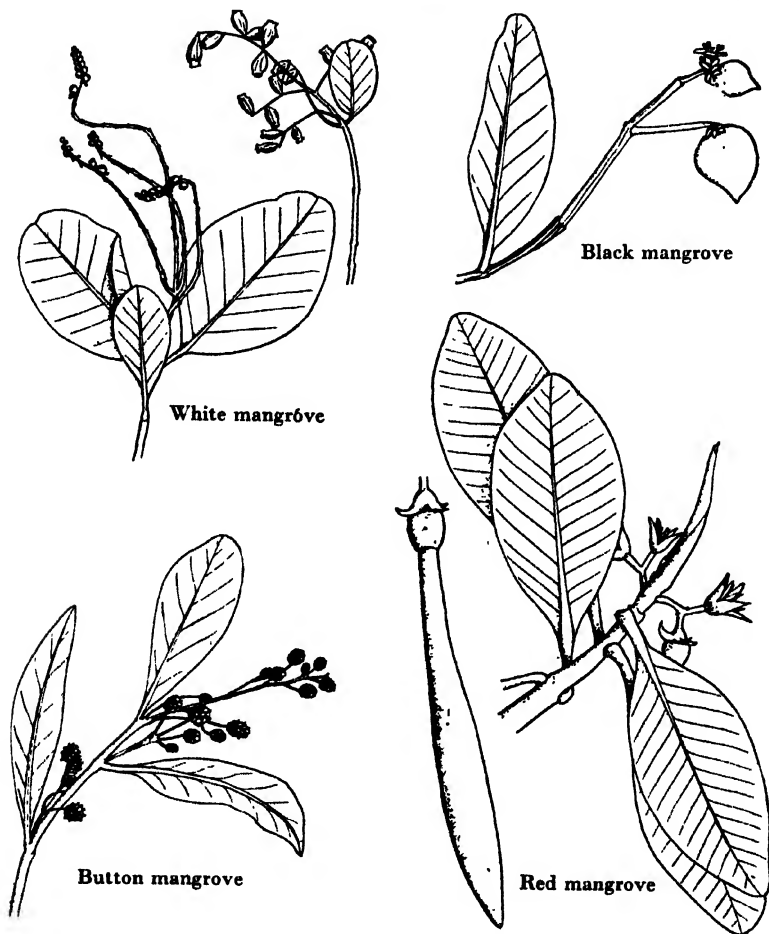
TEXT-FIG. 14.

TEXT-FIGS. 11-14. Vegetation maps. Fig. 11 of Gun Cay; fig. 12 of Maiden Cay; fig. 13 of South Cay; and fig. 14 of South-east Cay. Scale as for Text-fig. 7.

South Cay is a narrow islet dominated on the western half by a pure stand of tall *Rhizophora Mangle*, whilst much of the eastern half is occupied by the same species together with *Laguncularia racemosa* (text-fig. 13). The eastern extremity, however, could be regarded as a dune area, bearing *Sesuvium Portulacastrum*, *Philoxerus vermicularis* and young bushes of *Thespesia populnea* and *Avicennia nitida*. The nearby South Rock was an accumulation of boulders with only *Sesuvium Portulacastrum*.

The two long arms of Drunkenman's Cay are sand-covered in part and both bore *Sesuvium Portulacastrum*, whilst the western arm had in addition a patch of *Sporobolus virginicus* and young bushes of *Avicennia nitida*. The southern section of the cay was covered with a mixed growth of *Rhizophora Mangle* and *Avicennia nitida*. Other species recorded from this area were: *Thespesia populnea*, *Tournefortia gnaphalodes*, *Laguncularia racemosa*, *Conocarpus erecta*, *Euphorbia buxifolia*, and *Sesuvium Portulacastrum*.

On all these cays, where there are dune areas, the *Sesuvium-Sporobolus-Ipomoea* associates is to be found, except that on Lime Cay there is evidence of a later stage which may be called a thorn-scrub associates.<sup>1</sup> *Batis maritima* occurs on these cays, but the present author agrees with other workers in relegating this plant to the mangrove seres.



TEXT-FIG. 15. Characteristic twigs of the four mangroves of the New World (from the *Geographical Journal*).

#### *Portland Bight cays*

I did not have time to visit these cays, but the observations and photographs of the other members of the expedition indicated that they showed no additional new features.

#### *Palisadoes (Plate 18)*

On the Palisadoes at least three distinct communities can be recognized, two of which are developmental whilst the third probably represents the edaphic climax under the prevailing conditions. The proximal end of the spit is formed of very low dunes, resting on a shingle and rock substrate. Much of the dunes was bare, but an open *Sesuvium*-

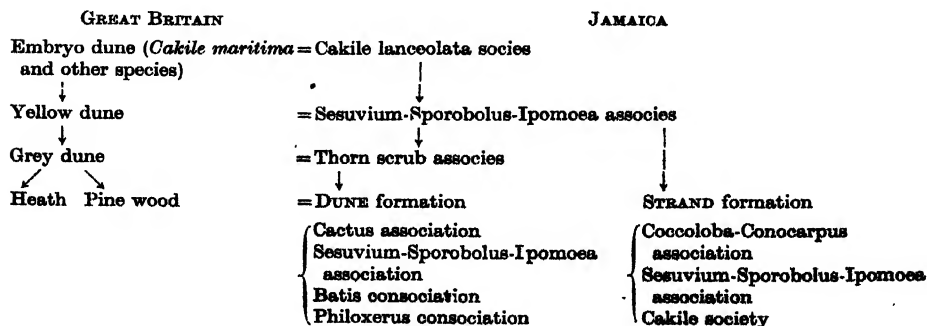
<sup>1</sup> Although terminologically incorrect, I prefer in this case to employ the general term because our premature departure did not allow us to study this phase very closely.

Sporobolus-Ipomoea associates spread over some parts (Plate 20, fig. 20). The same community could be seen again near Port Royal in the region where the road and disused railway run side by side. The characteristic species were: *Sesuvium Portulacastrum*, *Sporobolus virginicus*, *Ipomoea Pes-caprae*, *Canavalia obtusifolia*, *Boerhavia scandens*, *Euphorbia buxifolia* and *Tribulus cistoides*.

Proceeding westward along the Palisadoes the dunes and the creeping vegetation of the Sesuvium-Sporobolus-Ipomoea associates yields to a thorn scrub dominated by *Acacia*. A number of other species are associated with the dominants but a complete list was not made. Cacti, including *Opuntia Tuna* and *O. spinosissima*, are common, whilst *Thespesia populnea* and *Conocarpus erecta* grow near the edge of the mangroves. The essential feature of this associates is its shrubby character as compared with the creeping vegetation of the lower and more mobile dunes. Other shrubs found were *Jatropha gossypifolia*, *Coccoloba uvifera* (on the seaward edge), *Cordia sebestana* and *Calotropis procera*, whilst *Boerhavia scandens* persisted as ground vegetation in some places. On the whole, however, the plants of the previous phase tend to disappear, probably because of the light conditions. As the sand accumulates on account of the presence of the scrambling plants of the primary phase, so these plants are replaced by the shrubs (Plate 19, fig. 15), and the fixation of the sand is now not only due to direct binding action of the roots but also to the plants acting as wind traps and preventing the sand from being exposed to the wind. The ground vegetation becomes sparse, and if the wind had access the sand would quickly be eroded. The dense scrub, however, acts very efficiently, whilst in the more open areas plants of the earlier stage still persist and keep the sand stabilized.

As the dunes become still older and higher, e.g. around Plumb Point and Little Plumb Point, the thorn scrub is invaded by *Cereus peruvianus* and other cacti until the final edaphic climax of a cactus association is attained. This forms a very dense thicket (Plate 19, fig. 16) and stabilizes the sand not only by means of the roots but also through breaking the force of the wind. *Guaiacum officinale* (lignum-vitae) is a common tree of this association, whilst the following species were also recorded: *Heliotropium curassavicum*, *Boerhavia scandens*, *Euphorbia buxifolia*, *Jatropha gossypifolia*, *Melocactus communis* and *Cereus triangularis* growing as an epiphyte on *C. peruvianus*.

It should be clear from these descriptions that so far as the first and second phases are concerned parallel types of vegetation can be found on both the cays and the Palisadoes. In the absence of any data suggesting further change the cactus association is regarded as representative of the climax community. This climax vegetation forms part of the Dune-Strand formation of the Caribbean. Comparing the vegetation of these dunes with those of Great Britain, a parallel sequence of events can be observed in which community succeeds community with increasing height and age of the dunes. One may further prophesy that the organic and carbonate contents of the sand will show comparable drifts to those described by Salisbury (1925) for English dunes:



Börgesen considered that the *Coccoloba-Hippomane Mancinella* community of the Danish West Indies was more or less equivalent to the grey-dune stage, but from the accounts it would appear more correct to regard this community as forming part of the strand formation.

In Great Britain the slacks and lows lying between dune ridges have a high water-table and the vegetation frequently shows a more halophytic character. In Jamaica a similar type of habitat is to be found, and in such areas one finds consociations of either *Batis maritima* or *Philoxerus vermicularis*. It is probable that so long as the dune vegetation is stabilized the *Batis* will persist and does not, in fact, form part of a seral sequence. In recognition of this fact it is regarded as a component community of the Dune-Strand formation. The characteristic association of these two plants with this type of habitat has also been commented upon by Raunkiaer (1934).

### 3. THE MANGROVE VEGETATION

The study of the Jamaican mangroves was confined to the regions around Kingston and Portland Bight and to the neighbouring cays. In spite of this restriction, however, it would seem probable that the descriptions and conclusions are valid for the Jamaican shore-line as a whole.

The evergreen mangrove forests, their stems bathed in sea water and with crowns of dark silvery green leaves, have been a source of interest from early historical times. The earliest mention is in Theophrastus (305 B.C.), when he writes of the Persian Gulf that 'the trees are all washed by the sea up to their middle and they are held up by their roots like a polyp'.

There are very few later references until the sixteenth and seventeenth centuries, when descriptions of mangrove forests from different parts of the world began to appear. In the latter half of the nineteenth century the morphologists commenced to describe the structure of the various mangrove species (Goebel, 1889; Schenck, 1889; Karsten, 1891), whilst serious ecological study began with Schimper (1891). Since then there have been several accounts of the ecology and geologic rôle of mangroves in different parts of the world. Four accounts in particular can be regarded as making important contributions to the study of this peculiar vegetation. There is the paper by Troll & Dragendorff (1931) on the pneumatophores of *Sonneratia alba*; the description of the Malayan mangroves by Watson (1928); the account by Walter & Steiner (1937) of the ecology of the East African mangroves; and the recent paper by Davis (1940) on the ecology of the swamps in Florida.

*Salt tolerance.* It has been pointed out by both Schimper (1936) and Davis (1940) that mangroves cannot be regarded as obligate haline plants because a number of species are capable of growing in fresh water. It is possible that all the species can do this, but at present we lack the necessary experimental evidence. Davis has grown *Rhizophora* for 30 months and *Avicennia* and *Laguncularia* for 24 months under fresh-water conditions. The present author similarly had a healthy four-year-old plant of *Avicennia nitida* growing in the Cambridge Botanic Gardens. The amount of sodium chloride present in the environment is said to modify structure, reproduction, time of flowering and seed



TEXT-FIG. 16. A healthy plant of *Avicennia nitida* grown to the age of 4 years in the University Botanic Gardens, Cambridge.

germination, but further confirmation of this is required. In respect of sodium chloride tolerance Schimper (1936) divided the Old World mangroves into four categories: this classification is reproduced below with the tentative addition of the New World mangroves.

Narrow salt tolerance		Wide salt tolerance	
1	2	1	2
High optimum <i>R. mucronata</i>	Low optimum <i>R. conjugata</i>	High optimum <i>R. Mangle</i> <i>A. officinalis</i> <i>A. nitida</i>	Low optimum <i>L. racemosa</i> <i>C. erecta?</i>

The present author believes that none of the mangroves of the New World falls into the first two categories with the possible exception of *Conocarpus erecta*. It is believed that both *Rhizophora Mangle* and *Avicennia nitida* possess a wide salt tolerance. *Laguncularia* and *Conocarpus*, which normally grow near the inland border of the swamps, nevertheless do occur in areas where there is a considerable concentration of sodium chloride in the soil, but it is clear that their optimum development takes place in areas where the sodium chloride concentration is low. This table emphasizes the difference in tolerance between the three species of *Rhizophora*, whilst the wide salt tolerance of *R. Mangle* may mean that on ecological grounds it is the most primitive species.

Salt marshes of temperate regions occupy areas between high- and low-water marks, and mangrove swamps also occur in such localities; mangroves have a greater vertical range because they extend from below low-water mark to above the line of the highest tide. They not only occur on soils washed by haline or brackish water but quite often on areas, e.g. reefs, sand-banks, that are relatively dry. Schimper (1936) considered that the mangrove habitat is more extreme than that of salt marshes because of the greater variation, but it is doubtful whether this statement could be sustained.

#### Ecological classification

One of the most recent schemes for ecological classification is put forward in the paper by Tansley, Watt & Richards (1939). These authors propose that the mangrove vegetation throughout the world should be regarded as a formation type. This would be subdivided into two formations, the mangrove formation of the New World (including also the shores of West Africa) and the mangrove formation of the Old World: the tidal swamps of Australia would belong to this second group, though when more is known about them it may be necessary to establish a third formation for Australasia. The species of *Avicennia* are very distinct in their distribution and segregate readily into these three geographical regions. Börgesen (1909) and Raunkiaer (1934)<sup>1</sup> have both recognized a mangrove formation in the West Indies in which *Rhizophora Mangle*, *Avicennia nitida* and *Laguncularia racemosa* are the dominants, whilst *Conocarpus* is placed in a separate formation. Chipp & Burt Davy (1938) recognized a mangrove formation in tropical Africa: Schimper (1936) describes a woody formation (really a formation type) of mud flats which he subdivides into the eastern and western mangrove formations. None of these classifications, however, allows for mangrove development on reefs or sand. In addition to the mangrove and *Conocarpus* formations Börgesen recognized a *Salicornia* formation and Schimper an open formation of mud flats dominated by *Salicornia ambigua* accompanied by *Batis maritima* and *Sesuvium Portulacastrum*. One must also mention the sea-grass formation described by Börgesen (1909), since in certain localities this may play a part in the successional development. The primary components in the West Indies are *Cymadocea manatorum* and *Thalassia testudinum*. The algal genus *Halimeda* is also important because of the capacity of its species to form mound-like banks which may eventually become exposed.

Börgesen (1898) regarded the mangrove formation in the West Indies as essentially a vegetation of muddy soils, but this is by no means the full story; on sheltered coasts

<sup>1</sup> Beard (1944) recognizes this formation in the Trinidad region.

it occurs on gravel, mud, clay or rocks which may or may not be inundated with brackish or salt water. The open *Salicornia* formation is described as occurring where mangroves are absent or scattered. On the whole, however, *Salicornia* would not appear to be common, and if such a community is to be recognized in Jamaica it should be called an associates. *Batis maritima* is far more frequent on the open salinas and *Salicornia* was not found by our party around Kingston; even Börgesen could not report it as common in the Danish West Indies. In his first paper (1898) Börgesen placed *Conocarpus erecta* in the mangrove formation, but in the second (1909) he treated it as an independent formation. If the species is abundant it commonly occupies an intermediate zone between the mangrove swamps and the dune vegetation, and could therefore be regarded as belonging to either or else as a separate entity. The soil is usually mixed with some sand and is firmer and drier than that of the main swamps. Raunkiaer (1934) divided the mangrove formation into three facies dominated respectively by *Rhizophora Mangle*, *Avicennia nitida*, and *Laguncularia racemosa*, and the *Conocarpus* formation into four facies dominated by *Conocarpus erecta*, *Borrchia frutescens*, *Pluchia odorata* and *Acacia farnesiana*. He also attempted to compare these facies with the corresponding salt-marsh associations recorded from the Island of Fåno in Denmark. This, however, involves difficulties because, not only is there a great difference in tidal range between the two areas but also the life forms of the component species differ. Under these circumstances it is doubtful whether the comparison is of any real value; in any case there is the problem of how far the last three facies of the *Conocarpus* formation are really halophytic, although both *Borrchia* and *Pluchia* are typical plants of the higher salt marshes in Carolina, Georgia and Virginia. Without laying any stress on such comparisons the present author would suggest the following version.

TABLE III

	WEST INDIES (Raunkiaer)	Ground vegetation	DANISH (Raunkiaer)	BRITISH (V.J.C.)
Mangrove formation	<i>Rhizophora</i> facies	—	—	Bare mud
	<i>Avicennia</i> facies	—	—	<i>Salicornia</i> and <i>Salicornia-Aster</i>
	<i>Laguncularia</i> facies	<i>Salicornia ambigua</i>	<i>Salicornia herbacea</i>	General salt-marsh vegetation
Conocarpus formation	<i>Conocarpus</i> facies	<i>Batis maritima</i>	<i>Glyceria maritima</i>	<i>Glyceria</i> or <i>Plantago</i>
	<i>Borrchia</i> facies	<i>Juncellus laevigatus</i>		<i>Juncus Gerardi</i> — <i>Juncus maritimus</i>
	<i>Pluchia</i> facies	<i>Sporobolus virginicus</i>	<i>Juncus Gerardi</i>	<i>Juncus maritimus</i> — land vegetation
	<i>Acacia</i> facies	<i>Stenotaphrum</i>	<i>Armeria maritima</i>	Dune vegetation

So far it has tacitly been assumed that we are justified in regarding the mangrove forests as an ecological formation. Watson (1928), however, has suggested that it should be regarded as an association of the tropical rain-forest formation, whereas Davis (1940) has pointed out that the mangroves are essentially seral communities. It is probable that Davis is not strictly correct, because the reef and sand (see below) mangroves appear to be more or less stable and hence represent a climax formation. The mud and peat mangroves form a dynamic vegetation in which definite successional stages can be observed. These stages in the West Indies do not reach their climax in either the *Laguncularia* or *Conocarpus* communities, because under suitable conditions further development will take place via a salina to thorn savannah or alternatively either directly or with an intermediate fresh-water marsh phase, to a climax of tropical or subtropical forest (cf. p. 443). The true climax formations in the West Indies, therefore, appear to be the tropical forest or the thorn savannah.



TABLE IV

Schimper	Burt Davy, Tansley, Watt and Richards	Borgesen	Raunkiaer	Davis	Chapman
Woody formation of mud flats:	Mangrove forma- tion type:	—	—	—	Mangrove formation type:*
(a) Eastern mangrove formation	(a) Eastern mangrove formation	—	—	—	Reef and sand cays { (a) Eastern mangrove formation (b) Western mangrove formation
(b) Western mangrove formation	(b) Western mangrove formation	Mangrove formation	Mangrove formation <sup>1</sup> <i>Rhizophora</i> facies <i>Avicennia</i> facies <i>Laguncularia</i> facies <i>Conocarpus</i> formation	Rhizophora consocieties Avicennia consocieties Laguncularia consocieties Conocarpus consocieties	New World mangrove sere Avicennia consocieties Laguncularia consocieties Conocarpus consocieties
Open formation of mud flats	—	Conocarpus formation  Salicornia formation	<i>Conocarpus</i> facies  <i>Borreria</i> facies <i>Pluchea</i> facies <i>Acacia</i> facies	Salt-marsh associates  Beach or dune associates	{ North South Salt-marsh associates Salina associates DUNE-STRAND formation

\* The stability of these communities is discussed in more detail later (cf. pp. 434, 440).

<sup>1</sup> Beard (1944) recognizes only one association in the Mangrove formation of the Trinidad region.

In the West Indies the tropical rain forest and thorn savannah represent climatic and edaphic climaxes respectively, and although the mangrove vegetation of the New World, and probably also of the Old World, is climatically delimited by temperature (cf. p. 432), nevertheless it is also determined edaphically by the presence of sodium chloride in the soil. Davis believes that these forests are determined primarily by the edaphic rather than the climatic factors. The great interest of the mangroves is now apparent because it is evident that we have not yet arrived at a complete understanding of their status. Although these forests are climatically and edaphically determined, there is also a physiographic element in their formation because they will only develop to any extent (a) where the shore shelves gradually, (b) where the coast is more or less protected, (c) where there are rivers bringing down sediment.

Table IV summarizes the classifications of the different authors.

#### *Habitat classification*

In a description of the East African mangroves Troll & Dragendorff (1931), and later Walter & Steiner (1937), recognized two types of mangrove woodland:

(a) Mud mangroves growing principally near the mouths of rivers.

(b) Reef mangroves growing among the rocks and boulders of coral reefs and cays.

As a result of our studies it would seem desirable to add two further categories:

(c) Sand mangroves growing on sand shoals, sand bars and sand cays.

(d) Peat mangroves growing usually along the shores of sheltered coasts where the rivers do not bring down much detritus or else where there are no rivers.

Categories (a) and (d) together are equivalent to Watson's (1928) group of 'accretion mangroves', whereas (c) is partially equivalent to his group of sand mangroves, but as this category was reserved for those growing only on sand shoals the present grouping is more comprehensive.

The only other alternative classification is that given by Stephenson & Tandy (1931) for the mangroves of the low wooded islands of the Great Barrier Reef. Such swamps were divided into (a) dense woodland, (b) muddy glades, and (c) shingle tongues. The dense woodland was characterized by a thick growth of *Rhizophora mucronata*, whilst around the margins of the muddy glades there was a growth of *Bruguiera Rheedii*. Any shingle tongues on which mangroves grew were regarded as antedating the tree vegetation. Such areas possessed a distinct ground flora and other trees, e.g. *Thespesia populnea*, were admitted with the mangroves. This classification, however, is not of such general applicability as the one described above. From the description given in the report the dense woodland and muddy glades belonged to the mud mangrove category, whilst those on the ramparts were true reef mangroves.

#### *Systematics*

The mangrove vegetation of the Old World, with the exception of the west coast of Africa, is characterized by the presence of a number of species, whereas the western mangroves only contain four species, and of these one, according to some authors, is doubtfully classed as a mangrove.

#### RHIZOPHORACEAE

*Rhizophora Mangle* Linn. Mangrove, red mangrove (text-fig. 15, and Plate 18). The trees of this species have short stems supported by so-called prop roots, whilst there are also aerial strut roots which grow down from the upper branches, both prop and aerial roots having distinct black root caps. According to Watson (1928) the height of production up the trunk and the degree of spread of the prop roots in the Malayan species of *Rhizophora* is dependent on environmental factors. Davis (1940) has noted in Florida, and we have confirmed in Jamaica, that the offshore side of a tree growing on the strand sends out more extensive prop roots than the onshore side, but the exact nature of the

stimulus which produces this effect is purely a matter of conjecture. As the trees usually grow in sheltered localities the mechanical function of the so-called prop roots would appear to be a myth. The trees normally range from 10 to 50 ft. high although Davis records specimens up to 80 ft. in Florida; those around Kingston were of moderate height. Two growth forms of *Rhizophora Mangle* have been described from the Pacific coast of Central and South America and also from Florida, though it is possible that the size is partly determined by the density of the stand. One is a small form known as *mangle chico* (10–18 ft.) and the other is a large one known as *mangle grande* (60–80 ft.). The occurrence of two such distinct forms was not noted around Kingston, but they may occur elsewhere on the island.

The leathery leaves are oval or obovate-lanceolate, obtuse at the apex, entire, glabrous, shining green and 15 cm. long. Davis reports that in Florida there is a correlation between leaf size, structure, salinity and type of soil. The *stipules* are large and sticky, reddish in colour and are borne in imbricate pairs. The *peduncles* are normally 2–3 forked and support a few rather large and leathery flowers. The four *sepals* are lanceolate, thick and leathery. The four white or yellowish white *petals*, which are entire and inserted at the base of a fleshy disk, are lacerate-woolly on the margin, chiefly below the apex. Eight *stamens* are inserted with the petals and have very short filaments. The *anthers* are ultimately two-valved, acuminate and with small staminodes at the base. The half inferior *ovary* is two-celled with two ovules per loculus; it is prolonged above the calyx into a fleshy cone. The *style* is awl-shaped with a bi-dentate stigma. The leathery fruit, which is surrounded above the base by the reflexed sepals, is one-celled and one-seeded (text-fig. 15). The cotyledons are doubled up together, and as germination takes place whilst the fruit is still attached (vivipary) the long club-shaped radicle must first perforate the apex of the fruit before it grows down towards the mud. There is no resting stage between maturation of the seed and the beginning of germination. In Florida the fruit takes 2–3 months to ripen, the greatest quantity being produced during July and August; in Jamaica, Guppy (1917) states that the seedlings are 11–12 months on the tree, whilst in Fiji they are only 8–9 months. Fruits detached prematurely do not survive, but Guppy has shown that mature ones are capable of maintaining their vitality in the dry state for at least 6 weeks and perhaps for as long as 5 months. The hypocotyls are frequently curved, so that when such a fruit falls it does not stick in the mud but gets carried away by the sea.

*Rhizophora Mangle* does not secrete<sup>1</sup> salt, and Faber (1913) has suggested that there is a tannin mechanism for the control of the osmotic pressures in the tissues. *R. Mangle* is found from Florida to South Brazil on the Atlantic coast and from California to Ecuador on the Pacific. Elsewhere in the Pacific it occurs on Fiji and Tonga, where its distribution overlaps with that of the Old World species, *R. mucronata*. It is also to be found on the west coast of tropical Africa from the Senegal River to Angola. The African form possesses many-flowered peduncles and has been described as *R. racemosa* (cf. Meyer, 1818), but it is probably little more than a variety. If, however, the New World mangroves originated on the shores of West Africa *R. racemosa* would have to be regarded as the parent species and *R. Mangle* as a variety which is in the process of becoming a new species as a result of isolation. In Fiji there is also a third form known locally as *selala*; this is thought to be a cross between *R. Mangle* and *R. mucronata* with *R. Mangle* as the male parent, and many of its characters strongly suggest a hybrid nature. An alternative explanation is that *R. mucronata* is also dimorphic like *R. Mangle* and that the *selala* represents the other growth form. If this is the correct interpretation it is peculiar that this second form is not to be found in the Old World. It is perhaps worth noting that Guppy (1906) considered *mangle grande* to approach *R. mucronata* in many of its characters.

<sup>1</sup> For the use of this term cf. Frey-Wyssling (1935).

The bark of *R. Mangle* contains a high percentage of tannin, 20–40 %, and is extensively employed for tanning. Apart from this use of the bark the wood is hard and durable, especially if it has been seasoned; for this reason it is frequently used for posts and railway sleepers, whilst it also forms excellent firewood because it gives out an intense heat.

#### VERBENACEAE

*Avicennia nitida* Jacq. Black mangrove, honey mangrove (text-fig. 15 and Plate 18). The trees, which grow to 40 ft. and more, possess characteristic negatively geotropic aerial roots. The entire opposite leaves are lanceolate or lanceolate-elliptical, acuminate or bluntish, and in size are up to 18 cm. long and 8 cm. broad. They are leathery in texture and are minutely and closely pitted on the upper surface with a grey scurf beneath or else they are glabrate. The white flowers are crowded at the end of short peduncles, whilst the ovate imbricate bracts are shortly pointed and about 4 mm. long and tomentellous. The calyx is five-partite, coriaceous, with minutely ciliate margins. The corolla is subrotate with four lobes, one slightly unequal but all downy on both sides. The stamens are unequal and shortly exerted. The ovary is two-celled, each loculus containing two locules, whilst the bifid stigma has pointed lobes. The compressed fruit is leathery and one-seeded because three ovules abort (text-fig. 15). The species is viviparous, as germination takes place in the fruit. A single tree will produce about 300 seeds per annum, the maximum production coming from trees growing on clay. Guppy (1917) has recorded that seedlings will retain their vitality for 25 days with partial drying and after 50 % of their water has been lost. The bark contains about 12 % of tannin which is not sufficient to make it satisfactory for commercial use. Control of the osmotic pressure in the tissues of this species is probably secured by means of the salt-secreting glands which are to be found on the leaves. In the western hemisphere this species is to be found in the same localities as *Rhizophora Mangle*, except that it does not penetrate to the Pacific Islands. On the shores of tropical West Africa it is to be found from Senegal to Port Congo. The appearance of the species is slightly different on these shores and it has been known as *Avicennia africana* P. Beauv., but it does not seem sufficiently distinct to warrant segregation as a separate species. If the western mangroves originated in West Africa then var. *africana* would have to be regarded as the parent species. *A. tomentosa* Jacq., which is distinguished from *A. nitida* by broader leaves and sessile stigmas, is said to grow in a few Caribbean islands, and though recorded from Jamaica it was not seen in the vicinity of Kingston. Ridley (1936) reports New Guinea as the home of *A. tomentosa*, but it has probably been confused here with another species.<sup>1</sup> Schimper, on the other hand, restricts *A. tomentosa* to South America. The nature of the characters separating it from *A. nitida* suggest that it really should be regarded as a variety of that somewhat polymorphic species.

#### COMBRETACEAE

*Laguncularia racemosa* Gaertn. White mangrove, white button wood (text-fig. 15). This is generally a short shrubby tree, though sometimes it may reach a height of as much as 60 ft. The horizontal roots produce tuberous *pneumatophores* under certain conditions which are not yet known. The glabrous leaves are 5–11 cm. in length and 4–5 cm. broad, obovate or elliptical and with rounded or mucronate apices. The petioles bear a pair of glands towards the top. The flowers are subpaniculate and sessile on the axis, the ovate bracts which surround each flower being deciduous. The calyx and slightly clawed petals are both about 2 mm. long. The fruits are 1.5–2 cm. in length, shortly club-shaped and ribbed, and in Florida ripen mainly after August. The condition of the fruit must be regarded as a state of semi-vivipary because only in rare instances is a radicle found protruding: usually the embryo does not do more than rupture the seed

<sup>1</sup> Ridley in a letter informs me that his plant is distinct and will have to receive another name.

coat. Guppy (1917) reports that these fruits are capable of withstanding 2 weeks' drying. The wood is heavy and hard; and although the bark contains 12–24 % tannin, nevertheless it is unlikely to be of exportable value. In tropical West Africa the species occurs between Senegal and the Fernando Po with outliers in Angola. In the New World it extends from Florida to Rio de Janeiro on the east coast and from Lower California to Ecuador on the west coast.

*Conocarpus erecta* Jacq. Button tree, button mangrove, button wood, West Indian alder, Manglier gris, wild mulberry, Zaragoza mangrove (text-fig. 15). Some authors (e.g. Davis) do not consider this tree to be a true mangrove species, and although it commonly occurs on the sand beach, nevertheless it frequently penetrates the drier parts of mangrove swamps; for this reason it may be regarded as a mangrove, though not to the same extent as the other three species. It is an extremely variable species and appears to be very tolerant towards a variety of conditions. In this account of the Jamaican shore-line it will be regarded as occurring both in the mangrove swamp and the dune-strand habitats.

It is a small tree or shrub, 10–20 ft. high, erect, or trailing over rocks and coral boulders<sup>1</sup>. The roots do not produce pneumatophores. The glabrescent or glabrous leaves are 4–9 cm. long and 2–3.5 cm. broad, lanceolate to elliptical, acute at both ends and narrowed at the base into a short bi-glandular winged petiole which is often decurrent. The flowers are borne in dense ellipsoid heads which are more or less paniculate. There is a five-cleft calyx but no petals. The winged fruit is about 7 mm. across and has a thin impervious exocarp, whilst the endocarp is composed of a spongy aerenchyma on the outside with a hard layer on the inside. The wood is hard and heavy and burns slowly like charcoal. It is used as a fuel and also for building boats, barges and shelves because the wood is very durable if the trees have been grown on dry ground. The bark contains up to 16 % of tannin, but it is hardly of sufficient value for export. It grows in tropical West Africa from Senegal to south Nigeria, and so has the most restricted range of the New World mangroves on African shores. In the New World it is to be found from Florida to southern Brazil, whilst on the Pacific it occurs from Lower California to Ecuador with an outpost on the Galapagos Islands. Grisebach (1864) has described a variety *sericea* from Jamaica which is distinguished from the parent species by larger lanceolate leaves covered with a silky tomentum. In view, however, of the great variability of the species the status of this variety requires reinvestigation. It is reported from Old Harbour, from Portland Point to Rocky Point and on Pedro Bluff.

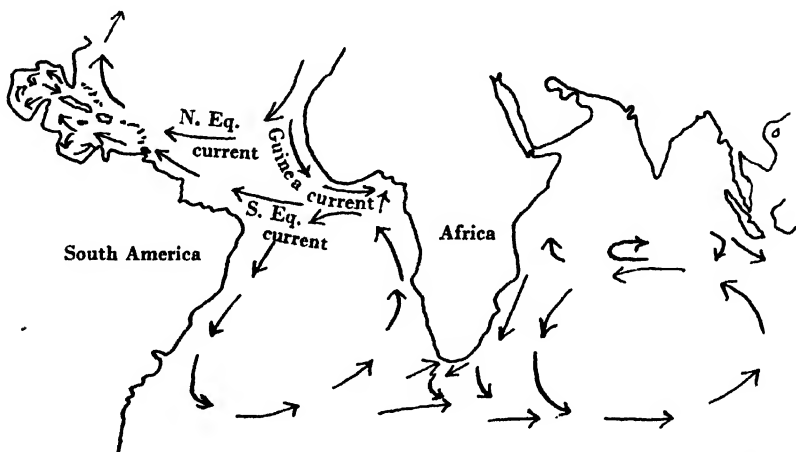
#### *Distribution and establishment*

In view of the greater number of mangrove species in the Old World it has been suggested that this type of vegetation originated in the Indo-Malay region, and that certain genera have subsequently spread to the New World. At one period Guppy (1906) believed that *Rhizophora Mangle* previously had a much wider distribution and that it had originated in the New World and spread to the Old via the Pacific. He also suggested that *R. Mangle* was now in a process of extinction; in view, however, of its recently reported occurrence in the Pacific at Tonga (Ridley, 1936) there is some reason to suppose that the reverse process is taking place. It is generally believed that the New World mangroves have been distributed by the South Equatorial Current (text-fig. 17) from the shores of tropical West Africa. This interpretation probably involves the assumption that *Rhizophora* and *Avicennia* arrived in tropical West Africa via the Cape; but this leads to certain difficulties. The flora and fauna of the shores of West and East Africa are markedly distinct (Stephenson, 1939), and the present ocean currents could not be regarded as promoting migration around the Cape. It is possible that migration took place in the past when currents were somewhat different, and then changes in the currents have resulted in the development of these species through isolation. *Laguncularia* and *Conocarpus* must have originated in tropical West Africa, as the genera do

<sup>1</sup> In the interior of Grand Cayman Is. the trees are completely prostrate.

not occur elsewhere in the Old World, but it is extremely difficult to understand why the other mangrove species of the Old World were not capable of rounding the Cape either then or subsequently. Although the ocean currents may therefore explain how mangroves arrived in the New World, they still leave unsolved the problem of geographical isolation between the mangroves of East and West Africa.

Guppy has reported that whilst 5% of the mature seedlings of *Rhizophora Mangle* sink at once, 80% will still float after 90 days in sea water and 20% after 120 days: some will even float for 12 months without harm, so that there is ample time for the ocean currents to bring about their distribution across the Atlantic. Similarly, seeds of *Avicennia nitida* will remain viable for 3–4 months in sea water whilst those of *Laguncularia racemosa* last even longer. If mangroves arrived in the New World through the medium of the South Equatorial Current, further spread by ocean and offshore currents would take place up the coast of South America to the South Windward Islands. Apart from major ocean journeys spread is mainly confined to adjacent coast areas, and this must be brought about by the tides and the winds. It is a considerable distance,



TEXT-FIG. 17. A map of ocean currents to illustrate the distribution of the mangroves.

however, from the Windward Islands to Jamaica and the Morant cays, and hence the argument developed on p. 419 to account for the absence of mangroves on the Morant cays deserves serious consideration. Davis (1940) has estimated that there must be enormous numbers of *Rhizophora Mangle* seedlings afloat in any given area where it occurs: e.g. around Florida he calculated that there are about 10,000 seedlings floating off those shores in any given year. Once the ocean has been crossed and migration begins along the coast the spread may not be so rapid because the outflow of fresh water from the rivers lowers the salinity, and under such conditions fewer seedlings of *Rhizophora Mangle* can remain afloat. Unfortunately, there are no comparable data for *Avicennia nitida* and *Laguncularia racemosa*. In fresh water Guppy (1917) reports that 20–50% of the mature seedlings of *Rhizophora Mangle* sink at once, whilst Davis, using a batch of seedlings placed in sea water of specific gravity 1.02 found that 98% floated horizontally, 40% floated vertically after 10 days and 100% reached that state after 35 days when some had sunk to the bottom. In brackish water, however, 98% reach the vertical position after 25 days, and this more or less confirms Guppy's observations that seedlings float horizontally in sea water and vertically in freshwater. It would be very desirable to have some data on the time taken for a seedling to drift across a river mouth. One could then compare this time with the time when the seedlings float

vertically and either ground or sink. In sea water the heavy end of the seedling balances the longer and lighter end, but with increasing age or in fresh water the seedlings become unevenly weighted and sink, a phenomenon that may be due to carbohydrate changes, although this is a field for future inquiry.

On the Schimperian view mangroves were regarded as confined to areas in which rain forest formed the vegetation of the hinterland, and it was suggested that a correlation existed between mangrove and rain forest climate. However, mangroves are not wholly absent from drier areas where there are large rivers or even, in the case of the Palisadoes, where there are no large rivers. It would therefore seem somewhat doubtful whether this correlation with rain-forest climate does exist although there may be some relation to the degree of humidity. A rain-forest climate in the hinterland does not necessarily mean that the same exists on the adjacent coasts. A study of the distribution of the mangroves in relation to the January and July isotherms is illuminating when we consider possible factors responsible for limiting their spread either north or south. The mangroves of both the Old and New Worlds do not extend north or south of the 17.7°C. January and July isotherms, except perhaps on a small part of the Great Barrier Reef. Davis (1940) points out that minimum temperatures are important because the western mangroves will not tolerate hard frosts or temperatures below 25° F. It is possible that they may suffer very occasional frosts in Florida. Guppy (1917) has suggested that they were much more widely distributed in the past when a warm climate was more uniform, and he also considered that vivipary may have been the rule rather than the exception as it is at present. The alternative view is that vivipary in plants is a relatively recent development, and Haberlandt (1918) regarded it as an adaptation to the peculiar environment of the mangroves. It would perhaps be advisable to suspend judgement on this phenomenon: it may well be a response to certain conditions of the environment, e.g. the salt of the water or the continual flooding.

A detailed study of the Florida cays by Lansing & Millsbaugh (1907) showed that for new ground the order of arrival of the mangrove species was *Rhizophora*<sup>1</sup> first, then *Avicennia*, *Laguncularia* and finally *Conocarpus*, but this may vary for different parts of the Caribbean. Following their arrival, establishment in any area will depend upon (a) tidal range, (b) amount of wave action, (c) rate of sedimentation, (d) substrate, e.g. mobile sand is a most unsuitable habitat for young *Rhizophora* seedlings. With regard to tidal range it is known that *Rhizophora* will rarely establish itself in water where the average depth of flooding is 2 ft. or more, and the small tidal range in Jamaica undoubtedly acts as a limiting factor to seaward spread. *Avicennia* and *Laguncularia* are not able to establish themselves where the average depth is more than 6 in. Although *Rhizophora* seedlings are not able to tolerate submergence to any great depth they are apparently capable of surviving persistent submergence to a depth of 1 or 2 in. above their plumule, whereas *Avicennia* and *Laguncularia* cannot. This must be one reason why *Rhizophora* is the primary seaward colonist in the West Indies where the tidal range is so small.

After establishment further spread, especially in relation to the salinity of the habitat, opens up one or two problems. In Fiji, *R. Mangle* is capable of tolerating brackish water and in Jamaica it can be found growing in the Black River swamps in association with water lilies. Guppy (1917) has suggested that in the latter locality the roots have penetrated to a layer where the salt water-table is to be found, but even so there is still the problem of the young stages. In such a case we may either suppose that the plants were established at a time when the land-sea level was such that the tide penetrated farther up the river, or else that seedlings commenced to develop in fresh water but that the roots soon penetrated to the subterranean salt water-table. In this latter case we are left with the difficulty of demonstrating how the seedlings became carried into

<sup>1</sup> Unless otherwise stated, the use of *Rhizophora* refers to *R. Mangle*, *Avicennia* to *A. nitida*, *Laguncularia* to *L. racemosa* and *Conocarpus* to *C. erecta*.

the fresh-water area, unless it were through the agency of a storm tide. It is greatly to be regretted that time did not allow us to attack this problem in more detail, because it is clear that the Black River morass in Jamaica offers exceptional opportunities in this direction.

### *Factors controlling distribution*

Descriptions of mangrove vegetation commonly state that it occupies the tidal belt, that is, the region between extreme high and low tide. Mangroves, however, have a much wider range than this: *Rhizophora* often occurs in places where the ground is perpetually covered with sea water. *Avicennia*, *Laguncularia* and *Conocarpus* all occur in places that are never covered by sea water, e.g. the Port Royal cays, although it is true that their roots may be in saline water. Furthermore, the tidal zone and brackish water region overlap in estuaries, and mangroves commonly penetrate the latter, even growing in completely fresh water, e.g. the Black River and its tributaries. As Troll & Dragendorff (1931) have pointed out, the estuarine transition zone is seasonal and its extent depends on (a) tidal range and (b) rainfall. Of these two factors the first is negligible in Jamaica, but the other factor may assume considerable importance during the rainy months (May and October, cf. p. 413). In an estuary where even the surface waters are quite fresh, Guppy (1917) has been able to demonstrate that the layers underneath may be appreciably saline. How far this complex of factors will affect mangrove vegetation will depend upon the age of the tree and the depth of root penetration: in view of the general tolerance of *Rhizophora* and *Avicennia* towards salinity range the latter feature cannot be very important.

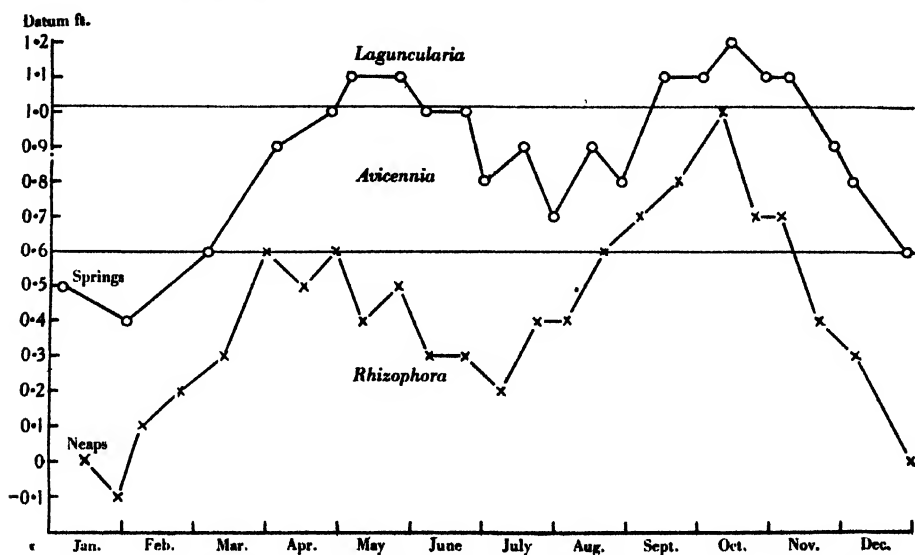
Other factors which have been suggested (Watson, 1928) as significant are drainage, character and depth of soil (emphasized also by Foxworthy, 1910; Troll & Dragendorff, 1931), age of the swamp, rate of accretion, erosive power of the sea together with the degree of shelter or exposure, and artificial conditions such as those produced by the construction of drainage canals. To what extent these factors operate generally in Jamaica will appear in the sequence, and also in another paper where the ecological factors controlling the distribution of *Avicennia nitida* are considered in more detail. There are yet other local or sporadic factors which may be important. Troll & Dragendorff (1931) and Davis (1940) have pointed out that there is a relationship between slope of the shore and the nature and width of the zones. In nearly all the Jamaican areas the slope is considerable, the rivers are short and the swamps form relatively narrow strips: exceptions are the swamps of the Black River and the Rio Cobre. In East Africa, the pioneer vegetation appears to depend to some extent upon the slope, but this does not seem to be true in Jamaica.

As an example of a sporadic factor hurricanes may be mentioned. It is possible that they may be responsible for the absence of mangroves on the Morant cays, since they contribute towards the instability of these islets. It is known that hurricanes are capable of destroying mangrove vegetation: Raunkiaer (1934) records that areas in Krause's lagoon on St Croix were destroyed by the hurricane of 1889, and it is possible that a similar agency killed the trees in the lagoon on Salt Island in Portland Bight. The killing mechanism is believed by Börgesen to be drying out of the habitat by the covering of sand and gravel which is thrown up. This, however, hardly seems to be an adequate explanation, because the roots could still be in a permanent water-table. Another possible explanation may be that the actual exposure of the roots causes death; Davis (1940) believes that the trees are killed through the bark being stripped off.

In a consideration of the Malayan mangroves, Watson (1928) evolved a scheme of inundation classes ranging from class 1, where the roots were inundated by every high tide, to class 5, where they were only inundated by equinoctial or abnormal tides, e.g. once or twice a month. The small tidal range and small number of species in Jamaica makes an arrangement of inundation classes unnecessary. A more satisfactory treatment



is probably realized in text-fig. 18, in which the vertical ranges of three species are shown in relation to the heights of the maximum spring and neap tides. These curves emphasize the significance of only a few inches difference in height upon degree of submergence and exposure. *Rhizophora Mangle* is inundated by nearly all the tides except for brief periods in winter and midsummer; *Avicennia nitida* is flooded by the majority of ordinary and spring tides as well as by some of the neap tides; *Laguncularia racemosa* is normally only flooded by the higher spring tides, whilst *Conocarpus erecta* will be washed by abnormal or extremely high equinoctial tides.

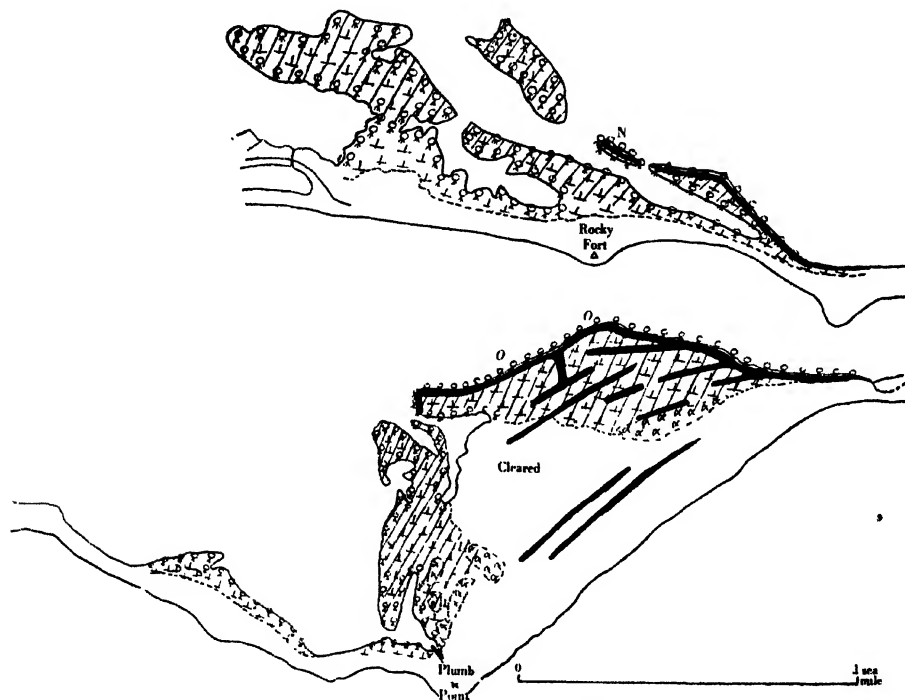


TEXT-FIG. 18. The relation of the mangroves in Kingston Harbour to neap and spring tides.

#### Mangrove types

*Reef mangroves.* Reef mangroves have been described from East Africa (Troll & Dragendorff, 1931; Walter and Steiner, 1937) and from the rocky ramparts of the low wooded islands of the Great Barrier Reef (Stevenson & Tandy, 1931), though here they must not be confused with the mangroves of the reef flat (Mangrove Park) which properly belong to the mud mangrove habitat. On the reefs the seedlings are deposited by the tide in crevices between the coral or rock boulders. Their arrival is determined by chance, successful establishment is difficult, and their subsequent existence is problematical because wave action may be considerable in such places. The root systems have to twine in and out of the boulders, and the low-spreading crowns of such trees or bushes, coupled with the wide-spreading root systems, indicates an unequal development of the root system in relation to tree size. In this type of habitat it is impossible to distinguish any clear zonation because the conditions are so heterogeneous. Furthermore, these mangroves cannot be regarded as taking part in the production of new land because the habitat is not suited to the perpetual trapping of silt, and all that can occur is further piling up of boulders or their removal by the sea. The habitat and vegetation are essentially static in character, and space occupied is usually severely circumscribed. There are not many examples of reef mangroves around Kingston. Young plants of both *Rhizophora Mangle* and *Avicennia nitida* are to be found growing among the boulders forming the south-east shore of Drunkenman's Cay (Plate 19, fig. 17), and a few young plants grow in the small bay on the south-east shore of South-east Cay:

there is also a small *Rhizophora* growing on the reef to the windward of Lime Cay.<sup>1</sup> In some cases the appearance of reef mangroves is fictitious, due to the fact that the trees commenced life on the edge of a sand cay and subsequent erosion has washed away the sand exposing the underlying coral and rock boulders. It is thus not uncommon to find old trees of both *Avicennia* and *Rhizophora* with one-half of the root system among coral boulders and the remainder in the heaped sand of the cay. This can be seen particularly well along the east shore of Lime Cay and on parts of South-east Cay. Examples of well-established reef mangroves can be observed on the south-west shores of South Cay and Drunkenman's Cay.



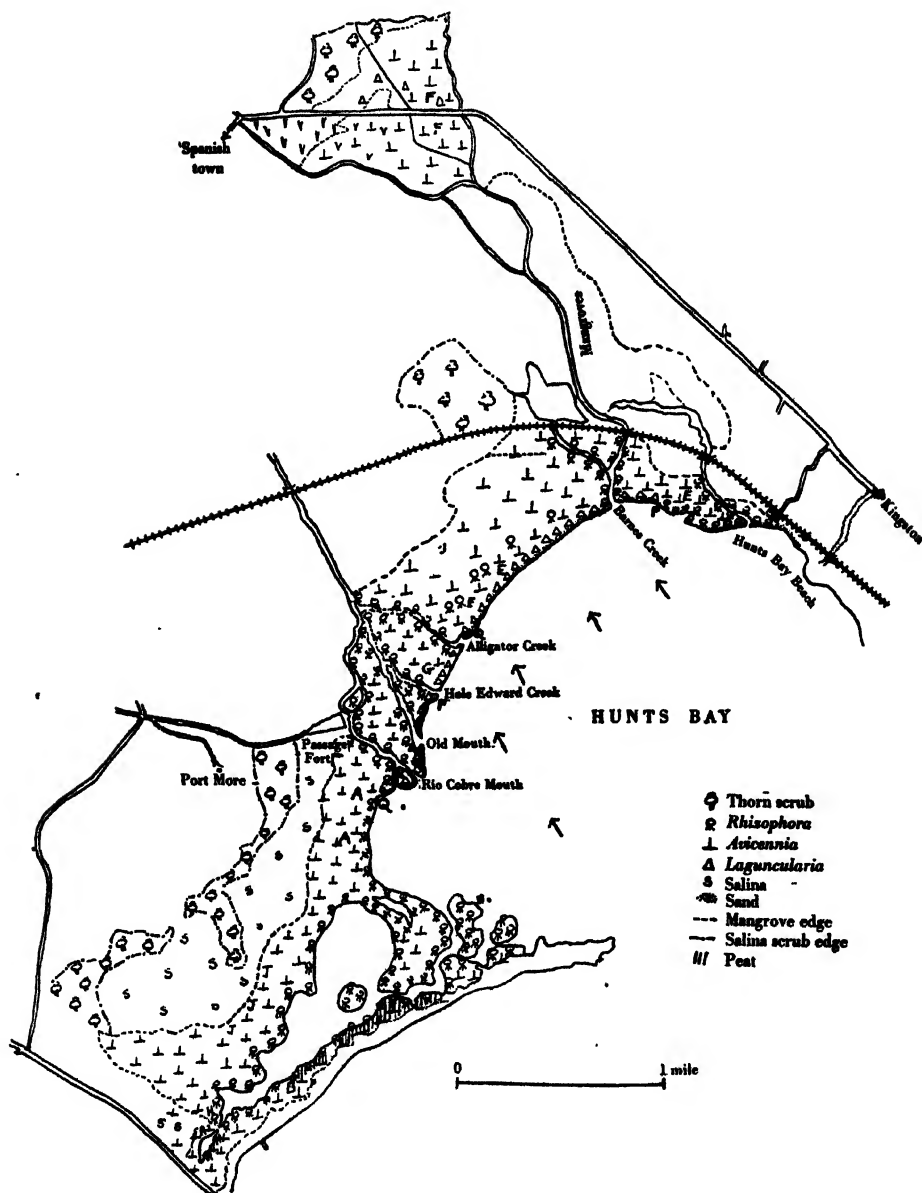
TEXT-FIG. 19. A mangrove vegetation map of the Palisadoes. For symbols cf. text-fig. 20.

*Mud mangroves.* In Kingston Harbour the principal areas studied were situated in Hunts Bay and around Dawkins Pond. The mud mangroves are those most intimately concerned with the production of new land (cf. later), and yet in certain circumstances erosion may outweigh accretion. In Malaya and East Africa the mud mangroves form a dynamic vegetation where there is a definite relation between the slope of the shore, the tidal range and the vegetation zones. The extremely small tidal range, 9 in.—1 ft., in Jamaica and the abrupt descent to the sea allows only a narrow intertidal zone and consequently it is not easy to distinguish clear vegetation zones. In Florida, where the slope is more gradual and large areas are occupied by mangroves, Davis (1940) has been able to describe the successional zones in some detail. The various habitats visited around Kingston that fell into this category could be regarded as possessing one of two soil types:

(a) Mud with a varying proportion of sand admixed. Such soils were found in the north-west corner of Hunts Bay (text-fig. 20, A) and on the Fort Augusta spit (text-

<sup>1</sup> These descriptions refer to 1939.

fig. 20, B); the landward part of the mangrove swamps along the Palisadoes in Old Harbour, Portland Bight, could also be placed in this category.

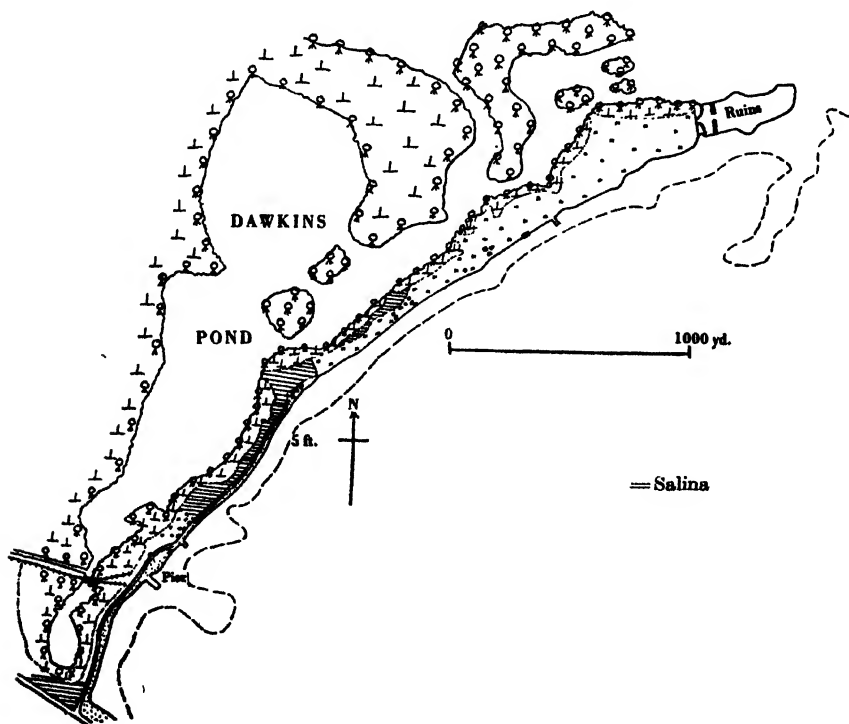


TEXT-FIG. 20. A mangrove vegetation map of Hunts Bay.

(b) A soft mud which it is more or less impossible to traverse. Samples of this were found along the Palisadoes (text-fig. 19, D), in Hunts Bay (text-fig. 20, E), up the Salt River leading to Spanish Town (text-fig. 20, F) and at the mouth of the Rio Cobre

(text-fig. 20, G), whilst some particularly soft patches were found around the inner small pond leading into Dawkins Pond (text-fig. 20, H), and also around the north edge of Dawkins Pond (text-fig. 20, J).

*Peat mangroves* (shaded on maps). This type has not been recognized before, but it is evident that they occupy considerable areas in Jamaica and even more extensive areas in Florida (Davis, 1940), and hence justify their segregation into a separate category. An alternative treatment would be to regard them as a subsection of the mud mangroves, but the ecological conditions involved in the formation of peat justify an independent group. The mangroves forming this type of woodland play a considerable



TEXT-FIG. 21. A mangrove vegetation map of Fort Augusta spit from a survey made by C. E. Hamshere. Symbols as in text-figs. 19 and 20.

part in the formation of new land but not to the same extent as the mud mangroves. Large areas of this type of mangrove are to be found in the swamps of the Palisadoes near Port Royal and near Plumb Point (Plate 18, fig. 13 and text-fig. 19). In fact, the clearance of the swamps at Plumb Point is only rendered feasible because of this type of soil. The peat is more or less absent in Hunts Bay and is not found again until we come to the swamps lying behind the Fort Augusta spit. Another group of mangroves growing on peaty soil were found at Galleon Harbour in Portland Bight, and there was a small patch in the centre of Careening Cay near the same locality: this latter provided the best example seen of peat formation on a cay.

We may now turn to a detailed description of the swamps that were visited in Jamaica. In the swamps along the Palisadoes between Port Royal and Rocky Fort there is a narrow fringe of *Rhizophora* on the outside with much *Avicennia* behind. Active re-

generation of both species is taking place, and the soil is primarily a peat with occasionally some sand present. *Batis maritima* forms an undergrowth in certain parts, whilst towards the landward edge *Laguncularia* becomes the dominant species. These mangroves along the Palisadoes are protected from heavy wave action because the shingle spit forms an effective barrier against waves caused by the south-east trade winds. In spite of this protection the trees are not large, probably because the wind can attack the crowns when they have reached a certain height depending on the size of the protecting dunes.

Two growth forms of *Avicennia* may be recognized which perhaps correspond to *mangle chico* and *mangle grande* in *Rhizophora*, e.g. (a) tall and (b) dwarfed and gnarled. It may be suggested that the small form is largely related to soil conditions. The dwarfed trees occur where there is little or no deposition of silt and the roots therefore form a dense mat of peat: this does not form such a good soil as there is no continual supply of fresh nutriment deposited from outside sources. Tall trees are invariably found in places where rivers are bringing down quantities of silt, e.g. around the Rio Cobre. The trees on the south shore of Dawkins Pond, where peat formation is also taking place, are likewise smaller in stature than those from the silted areas, though not so small as those on the Palisadoes. Rather larger trees are found in Galleon Harbour, but there the peat has more mud admixed and is virtually in an intermediate condition.

At Plumb Point there is an outer fringe of *Rhizophora* with pure or mixed stands of *Avicennia* and *Laguncularia* behind, all growing on a firm peat. In the mixed areas *Laguncularia* tends to be more abundant the nearer one approaches the dunes. In a few localities very close to the dunes, one may also find *Conocarpus*, thus indicating the intermediate position in the zonation of this species. Between these swamps and the proximal end of the spit there is only a narrow fringe of mangrove, mainly *Rhizophora*, and much of this has been badly mutilated by the construction of the road.

In Hunts Bay (text-fig. 20) the main swamps are occupied by a dense growth of *Avicennia nitida* with some local development, mainly on the seaward side, of *Laguncularia*; this distribution is related to a feature that is discussed later (cf. p. 440). *Rhizophora* is confined to the banks of streams, creeks and rivers where the water is quiet, and the distribution of this species in Kingston Harbour emphasizes its dependence on quiet sheltered conditions. These obtain in rivers and behind the Palisadoes and also in Dawkins Pond, and here *Rhizophora* is the pioneer species. Occasionally clumps of *Rhizophora* trees are found also in depressions in the main swamps or in areas where water is continually standing. The soil throughout this region is characteristically that of mud mangroves.

A short distance up Barnes Creek (the mouth of the combined Salt and Fresh Rivers) reed-swamp and other fresh-water vegetation appears and a fall in salinity can be recorded, as will be published in another part. There is, however, a considerable development of swamp on the left bank of the creek up to a point where the Salt and Fresh Rivers unite. Above this intersection considerable swamps occupy the ground between the two rivers, and it is here that they are traversed by the Kingston-Spanish Town Road. These swamps are probably relics of the time when salt water penetrated farther up the creek, or when they were associated with the old mouth of the Salt River (text-fig. 20). The principal species is *Avicennia* with some *Laguncularia*, both regenerating in profusion; but one also finds the halophytic fern, *Acrostichum aureum*, in some abundance (Plate 20, fig. 24). Its presence here supports Walter & Steiner's (1937) observations in East Africa that this fern only grows where there is some fresh water admixed. North of the main road the swamps give way to a salina or thorn scrub, but on the south side they merge into a fresh-water swamp dominated by *Typha domingensis* (Plate 20, fig. 23).

Between Barnes Creek and Alligator Creek there is a big development of mangrove swamp fringed on the front by a low growth of *Laguncularia racemosa* which is associated

with the protecting sand-pit. There is a small local development of reed swamp at the mouth of Alligator Creek. As soon as the main mouth of the Rio Cobre is reached the shore is protected from the trade winds by the Fort Augusta spit, and so the front is occupied once more by a narrow belt of *Rhizophora* with *Avicennia* behind. The whole of Dawkins Pond is lined by an outer fringe of *Rhizophora Mangle* with several islands of the same species in the pond and at its mouth. North of Dawkins Pond the *Rhizophora* fringe gives way to tall *Avicennia* behind, and then these gradually thin out, the trees becoming more and more scattered, until finally they pass into an open salina dominated by *Batis maritima* and *Sesuvium Portulacastrum*. The salina in turn gives way to a leguminous thorn scrub. It was evident, however, that the salina at one time had been covered with trees of *Avicennia*, as recognizable stumps could be found scattered over the region. The gradual drying up of this area is probably responsible for their disappearance, and such relics are visible evidence of the dynamic character of the vegetation. This drying up could be due either to small land movements in relation to sea-level, or to the gradual filling up of Dawkins Pond through continual accretion. This latter is probably the more likely explanation because C. E. Hamshire discovered evidence which indicated that the mouth of the Rio Cobre used to be in the neighbourhood of the present Dawkins Pond. With the removal of the river mouth to the east, silt has ceased to be deposited and the area has become much drier.

The Fort Augusta spit was remapped (text-fig. 21) because neither the Admiralty nor Pomeroy<sup>1</sup> maps were accurate for this region. It is also perhaps worth noting that the Admiralty map, Pomeroy map and a large-scale map from the Surveyor-General's office all show a different outline for Hunts Bay. It had been hoped that the expedition could remap the area, but this was prevented by the outbreak of hostilities. It would be very desirable to have it mapped accurately because one could then ascertain in the course of 25 years or so whether erosion or accretion were making the greater progress. A feature of interest about the swamps on the Fort Augusta spit was the development of two bare sandy salinas near its centre: on the first of these there was a small area with dead bushes of young *Avicennia*, which will be discussed more fully in a subsequent part. Bordering the dunes in this region there was also some *Conocarpus erecta*. The swamps along most of this spit were of the peat mangrove variety, with the exception of those bordering the small pond near Port Henderson: here the mud was particularly soft, probably because of the silt brought down by the adjacent drainage canal, and the trees were very luxuriant.

On Careening Cay in Old Harbour Bay there was an outer fringe of *Rhizophora Mangle* with *Avicennia nitida* in the centre growing on an incipient peat soil. There was no apparent regeneration of the latter species, and although plenty of seedlings were lying about none was taking root. Regeneration of *Rhizophora* could be observed on the north side: on the south side the water is too deep, and although the seedlings produce roots they do not develop any further because it is necessary for the apex to be out of water during some period of the day, and the small Jamaican tides do not permit of this. Goat Island bore an outer fringe of *Rhizophora* with *Laguncularia* and *Avicennia* behind, whilst over in Galleon Harbour, where there is considerable protection, there was again a well-developed fringe of *Rhizophora*. In the main swamp behind the fringe the *Avicennia* trees are tall and well grown and the soil, though not a pure peat, nevertheless has more than the normal proportion of organic matter present.

In the Black River, where *Rhizophora Mangle* is to be found 2½–3 miles up, the most interesting feature observed was the association of this species with water lilies and other fresh-water vegetation such as *Typha domingensis* and *Cyperus elatus* (cf. p. 433).

<sup>1</sup> The name given to the ordnance survey maps of Jamaica.

*Sand mangroves.* Mangroves of this category develop in three distinct types of locality:

(a) There are those growing on the sand cays, where they are well above actual tidal inundation although their roots will presumably be in a salt water-table. Such plants cannot play any part in the production of new land and merely serve as stabilizers of the sand. The distribution of the mangroves on the cays off Port Royal has already been described (cf. p. 419), but a few additional points may be noted here. On Gun Cay, Lime Cay and South-east Cay, bushy *Laguncularia racemosa* occurs on the higher parts: no pneumatophores are produced by the species in this habitat, and the exposure is at least partly responsible for their size and shape because they commonly indicate the effects of the south-east trade winds (Plate 20, fig. 22). Around the edge of the cays, normally on the leeward side, one may find clumps of *Rhizophora* or *Avicennia*, but there is little or no evidence of zonation. On Gun Cay there are occasional trees of *Avicennia*, whilst on South Cay and Drunkenman's Cay *Rhizophora* and *Avicennia* are indiscriminately mixed. Lime Cay is perhaps the most interesting of this group because there are two ponds, one lined with *Avicennia* near the windward shore and the other in the centre occupied by a clump of *Rhizophora*. Both species also occur on the windward side of the present cay. It would seem that these ponds may represent old shores of the cay which have subsequently become enclosed by the building up of a new beach. The long pond would then represent an old windward beach, but the presence of *Rhizophora* in the other pond would indicate that it might originally have been a leeward shore because this species can only establish itself in sheltered habitats. On Gun Cay, Lime Cay and South-east Cay, there are occasional trees of *Conocarpus erecta* so that all four species of mangrove are represented in this type of habitat. On none of these cays is there any indication of a zonation such as that recorded by Lansing & Millsbaugh (1907) for some of the Florida (Marquesa) cays. This is probably due to two or three factors: (1) their smaller size, (2) their greater exposure, because in no one cay is the development of *Rhizophora* comparable to that recorded for the Marquesas, (3) they may not be so stable.

(b) Those growing on sand shoals which are rarely or never exposed at low water. The Bogue Islands in Montego Bay are good examples, and there are also one or two shoals in Kingston Harbour near Port Royal, whilst Davis (1940) also records them from Florida. The presence of the trees encourages further accumulation of sand, and these shoals may gradually fuse and thus form considerable areas of woodland. This is certainly happening in all three localities mentioned above, and hence this type is very suited to the production of new land, although its formation is probably not so rapid as that which takes place at the mouths of rivers. In the Bogue Islands the dry land is only a very small portion of the whole area, but it is now sufficiently elevated to bear coconut palms and *Coccoloba uvifera*. The geographers were able to show that these islands have increased in size since they were last mapped and that some have become united during the process.

(c) The third type of habitat is that of the narrow sand-spits which are to be found bordering some of the swamps. Two excellent examples are to be seen in Kingston Harbour, the one behind the Palisadoes and the other in Hunts Bay; it seems evident that the type of vegetation they bear is directly determined by the degree of exposure. The sand-spit behind Rocky Fort (text-fig. 19 N) bears *Rhizophora* alone, though farther to the east it becomes wide enough to have *Avicennia* and *Laguncularia* behind. Where the swamps at Plumb Point are at their widest (text-fig. 19 O) there is again a long narrow sand-spit bordered on the outside by a fringe of *Rhizophora* with a pure stand of *Avicennia* behind growing in a firm peat. In both these places the swamps are protected from exposure by the Palisadoes and so *Rhizophora* is the pioneer species.

In Hunts Bay, however, the situation is materially different and one finds a narrow sand-spit (text-fig. 20 P-Q), fringed along most of its length by small bushes of *Laguncularia racemosa* with tall trees of *Avicennia* behind. A study of the map shows that this portion of the harbour is subject to considerable wave action every day from about

11 a.m. to 5 p.m. because of the south-east trade winds. It is this wave action which not only prevents seedlings of *Rhizophora* and *Avicennia* from establishing themselves, but also causes the sand-spit to travel landwards (Plate 20, fig. 25); in so doing it exposes the older plants of *Laguncularia* and *Avicennia* to erosion on the seaward side. This fact is obvious from the presence of old trees uprooted in the water in front of the bank and from the exposure of roots. Diggings and borings reveal swamp mud underneath the sand-spit, and the mud also emerges on the seaward side. The level of the mud on the seaward side is slightly lower than that of the swamp side, but this is a result of compression by the sand-spit as it passes over. Thus in this habitat we have the force of erosion versus the force of accretion, and it would seem from the superficial evidence that at the moment the former is making a slight headway. Accurate mapping of this region should, however, provide an answer to this problem in a comparatively short space of time.

### *The succession*

Before summarizing the succession in the neighbourhood of Kingston we may briefly consider other areas in the Old and New World. It is clear that in the Old World the order of zonation varies considerably in different localities, but usually species of either *Sonneratia* or *Avicennia* are the pioneers, except that in protected regions and along river banks *Rhizophora* species are frequently the first colonists. In Jamaica we find much the same because *Rhizophora Mangle* is the pioneer species in protected places. It is replaced by *Laguncularia* on sand-spits where there is intense wave action. In the Old World the transition to fresh-water swamp is often characterized by a *Nipa* association, whereas in Jamaica we find *Typha domingensis* and *Cyperus elatus*. In East Africa transitions from an *Avicennia marina* community to open salina have been recorded, and a similar progression can be observed in Jamaica and Florida (Davis, 1940).

In South America, Guppy (1917) recorded the following succession:

*Rhizophora Mangle* → *R. Mangle* → small trees of *Rhizophora* → mud flats with *Batis*  
 (chico) (grande) + *Avicennia tomentosa* and *Sesuvium*  
 (*nitida*?), *Laguncularia*  
 and occasional *Salicornia peruviana*

It is evident from later studies, including the present one, that this scheme only represents the broad outlines of the succession, and that in reality it is considerably more complex. The present author has already been forced to the conclusion that the succession on salt marshes is by no means a simple process, and the results of the present expedition, together with the recent paper by Davis (1940), now show a similar state of affairs for the mangrove swamps where previously only the simplest successions have been described, especially in the New World.

The most detailed account of the succession in the New World is that given by Davis (1940) for the swamps of Florida, and the principal communities which he recognizes are as follows, though they are not all necessarily part of the main series:

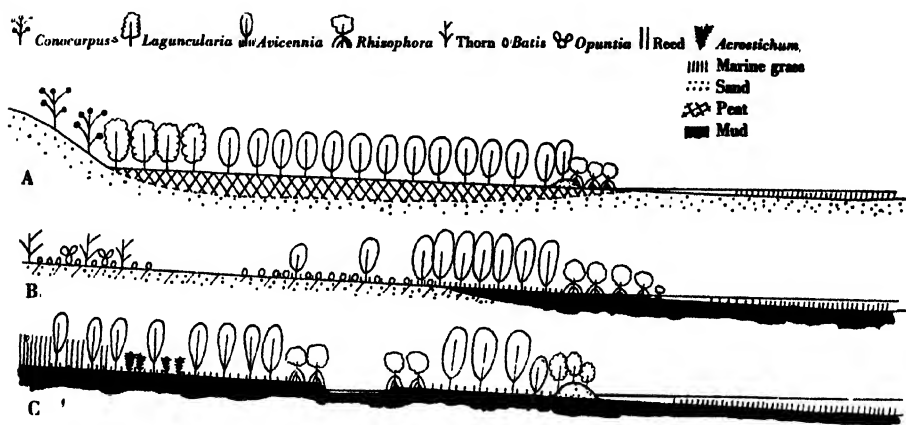
(a) *Pioneer Rhizophora family*. This is an open community of young mangroves, usually on submarine shoals in shallow undisturbed water. Around Kingston this family can hardly be regarded as present, the young mangroves forming a very narrow fringe in front of or beneath the existing trees of *Rhizophora*. This is because the tidal rise is small and the shore is not shallow enough for an extensive belt of young plants to develop. In other words, there is no likelihood of any great rapid extension of the Kingston swamps in the future as long as present conditions persist. The slow extension that will occur will largely be due to the prop roots extending seaward and collecting debris or else forming peat. An interesting feature of this family in Florida was the occasional presence of *Spartina alterniflora*. This is to be expected because Florida marks the northern boundary of the mangroves and the southern boundary



of the great salt marshes of North America, and so one finds a mixture of both types of vegetation.

(b) *Mature Rhizophora consociates*. This consociates consists of maturer trees which are so well anchored that only hurricanes can destroy them. This consociates can be recognized in Jamaica where it usually forms the outer fringe of swamps in protected areas.

(c) *Avicennia—salt-marsh consociates*. This is principally composed of *Avicennia*, *Batis maritima* and *Salicornia*. In the mature portions of the community there is no natural regeneration in Florida, and the community becomes more and more open or is replaced by *Conocarpus* or a marl prairie. Around Kingston *Batis* and *Salicornia* do not play any great part in the community except where there is a transition to a *Batis salina*, e.g. north of Dawkins Pond, and in such a place the *Batis-Avicennia* combination may be regarded as an ecotone community. The *Avicennia* community around Kingston and probably elsewhere in Jamaica, is best described as an *Avicennia* consociates because the salt-marsh elements are not sufficiently important to be regarded as co-dominants. This is a natural corollary of the more southern position of the Jamaican swamps and their greater distance from the northern salt-marsh vegetation.



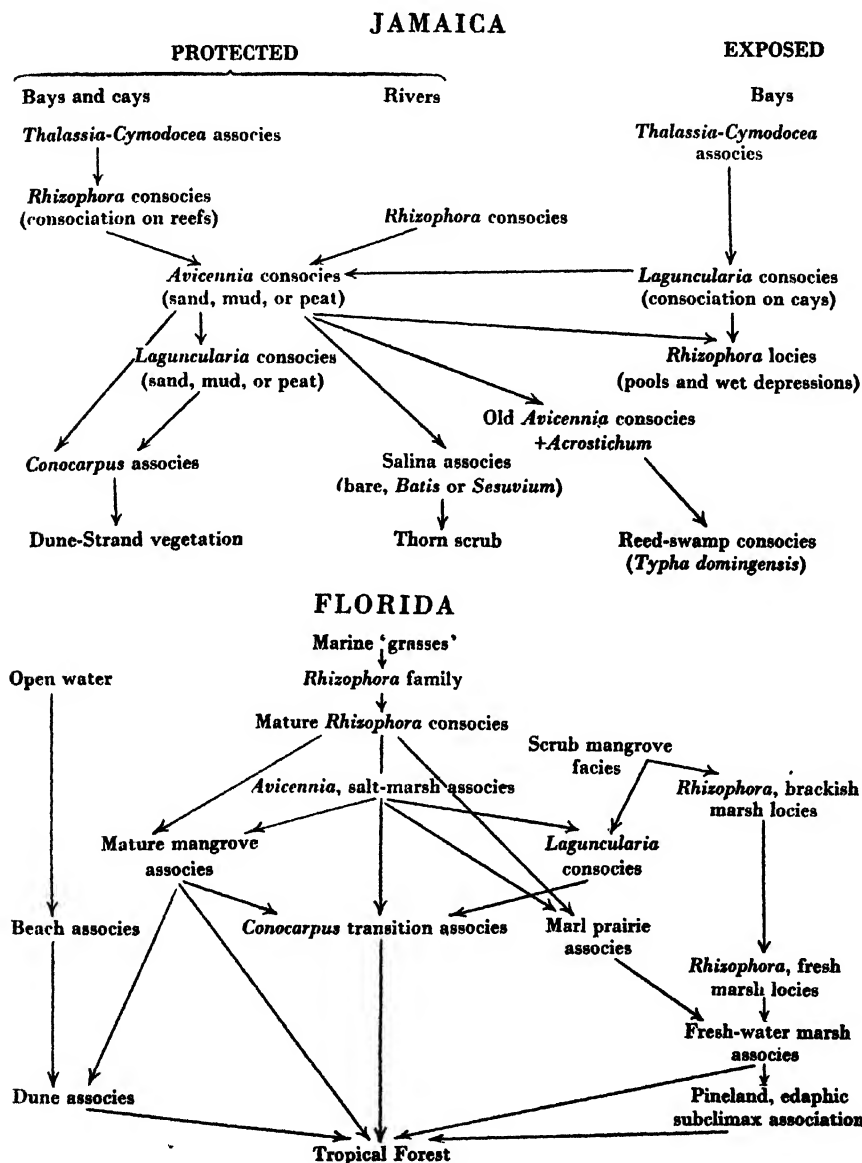
TEXT-FIG. 22. Diagrams illustrating the principal successional stages in the swamps near Kingston.

(d) *Mature mangrove associates*. This consists principally of large trees of *Rhizophora* and *Avicennia* on peat soils and growing in water that is not very saline. The nearest approach to this type of community was the *Avicennia* growth in Galleon Harbour, but in view of the great variability in growth of *Avicennia nitida* it does not seem justifiable to distinguish a separate community of large trees. It is also possible that the swamps near Kingston are not extensive enough to produce this type of community.

(e) *Laguncularia consociates*. In Florida this occupies no specific habitat, but in Jamaica the community is to be found on the landward side of the *Avicennia* swamps, e.g. Plumb Point on the Palisadoes, and also on the highest part of the sand cays where the trees are dwarfed. It also occurs on sand-spits on the seaward side of exposed swamps, e.g. Hunts Bay. It is not always present as a stage in the main sere.

(f) *Conocarpus transition associates*. Davis considers that in many respects this is an ecotone or transition community. In view, however, of the regularity of its recognition by previous workers (e.g. Raunkiaer, Börgesen) and from our observations in Jamaica it would seem more satisfactory to retain it as a definite seral community. There is great variation in the composition of the flora owing to the mangroves on the one side and sand dunes on the other. It is not a prominent community around Kingston, as the best examples were probably destroyed when the road along the Palisadoes was built.

(g) *Dwarf-form mangroves.* Davis recognizes a facies and two locies in this category. As the present author has not seen the swamps in Florida it is difficult to know to what extent these communities really differ and whether, in considering the variability of the



growth, one is justified in distinguishing such communities. The scrub mangrove facies consists of dwarfed *Rhizophora*, *Avicennia* and *Laguncularia*, usually growing near high-water mark. The nearest approach in Jamaica would seem to be the *Laguncularia* bushes found on the cays off Port Royal, but the present author does not see any valid reason

for separating them from the *Laguncularia* consociates. The *Rhizophora* locies of the brackish marsh associates does not occur around Kingston so far as the present author is aware. On the other hand, the *Rhizophora* locies of the fresh-marsh associates does occur in Jamaica in the Black River swamps. Davis suggests that the presence of the *Rhizophora* is due to storms or occasional high tides. The arrival of the seedlings must be due to some factor of this nature or else one must postulate a change in the land-sea levels. As Jamaica is a seismic region this is by no means impossible.

A summary of the zonations and the succession around Kingston is depicted in text-fig. 22, and in the scheme set out on p. 443 together with the comparable succession described from Florida.

### *Geologic work of mangroves*

The two types of woodland in which land formation proceeds most rapidly are the mud and sand mangroves, but we have already seen that even in the absence of a supply of silt the mangroves are capable of forming new land more slowly by the production of a marine peat. In Jamaica these peat soils are found in areas where there are no rivers or else where the rivers are small, e.g. the Palisadoes, Dawkins Pond, but in Florida they have apparently developed at the mouths of the rivers that drain the Everglades (White Water Bay to Cape Romano). Mangrove forest will develop most rapidly where there is plenty of silt or sand available, but, once established, the presence of their roots, together with the epiphytic algae and barnacles, greatly increases the rate of silt or sand deposition and hence hastens the formation of new land. In the accumulation of either sand or silt, the marine 'grasses', *Thalassia testudinum* and *Cymodocea manatorum* together with the algal genus *Halimeda*, play a not inconsiderable rôle in the accumulation of material in the earlier stages, since they raise the sea-bed to a level at which mangrove seedlings can establish themselves. At the mouths of rivers the silt-laden water spreads out and as it meets the flow is reduced, with the result that the suspended mud is deposited, the larger particles first and then the smaller. Some confirmation of this fact is given by analyses of samples collected at different sites up the Rio Cobre: in each site samples were taken at three different depths (Table V).

TABLE V. *Percentage of certain components in some soils*

	Mouth of Rio Cobre			Pollarded swamp			Up Rio Cobre		
	Surf	9 cm.	30 cm.	Surf	10 cm.	57 cm.	Surf	10 cm.	34 cm.
Coarse sand	93.26	93.71	90.76	39.93	34.58	34.90	26.45	18.79	18.1
Fine sand	1.55	0.78	3.03	26.48	24.69	20.76	38.7	35.62	37.9
Clay	1.53	0.32	0.22	5.05	14.32	13.55	5.77	10.47	13.3
Silt	0.37	0.68	0.70	15.65	18.93	15.05	20.55	17.20	16.0

Increasing distance from mouth of river.  
 → Decreasing percentage of coarse sand.  
 Increasing percentage of fine sand.

The currents, winds and tides are important factors in controlling soil accretion, and the irregular tides with long slack periods that occur in Jamaica will materially assist deposition. There is also a physico-chemical factor concerned, namely, the coagulating power of sea water on soil particles, and this comes into play at the mouths of rivers. Davis (1940) has also suggested that the precipitation of calcium carbonate may be important, but the present author believes that this is primarily confined to the marine grass phase and is not a major item in the Jamaican mangrove swamps.

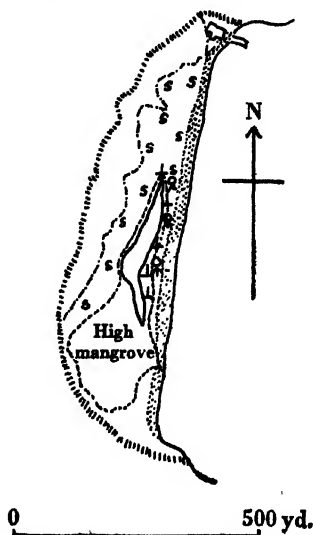
In those areas where there is little silt available and peat formation takes place instead, the decomposition of the plant remains is retarded, in the lower layers at least,

by the lack of oxygen, as will be shown by data to be given in a subsequent part, by the acidity of the material and also by the salinity of the water. Davis has segregated all these factors into three groups, the molar, physico-chemical and biotic, but to these it would seem that a fourth should be added, namely, seismic disturbances. This factor will assume different degrees of importance in various areas and in many it will be completely negligible. It cannot, however, be considered as such in Jamaica, because changes of land-sea levels may render it possible for mangroves to develop where previously they could not or vice versa.

Apart from the comparison of old and recent maps (though here the accuracy of the older maps may be questioned, especially since mangroves are so difficult to survey), Davis has suggested that one may employ soil profiles as a means of tracing swamp development, especially where there has been layering of strata. As in the case of salt marshes, the thickness of the peat is an indication of the time the swamp has been in existence, although some allowance must be made for subsequent compression. The fact that in some areas the peat is deeper than the maximum tidal range may be regarded as indicating either a gradual or a sudden change of the land elevation in relation to sea-level. In practice it should be possible to distinguish between one or the other, because if the change has been sudden it is more than probable that silt or sand would have to accumulate before more peat could form, so that the mature swamp would have a layer of sand or silt in the peat at some level. The depth of peat in the swamps near Plumb Point is greater than the present maximum tidal range and hence one may suggest that there has been past movement of the land in relation to sea-level.

Unfortunately, it was not noted at the time of sampling whether there was a distinct band of silt at any place in the profile.

Finally, there is the formation of new land by the development of sand tongues which grow out and enclose bays that then silt up and become colonized by mangroves. This is virtually what is happening in Kingston Harbour on a grand scale with the Palisadoes and the Fort Augusta spit acting as the two sand tongues. This process probably also occurred in the formation of Yallahs Pond and Albion Pond between Kingston and Morant, whilst one of the best examples is afforded by the Red Water Pond (text-fig. 23). As the water in the enclosed bay becomes foul the pioneer species are replaced by others and these in their turn disappear. Guppy (1917) has described how in the Salt Lakes district (between Kingston and Portland) first the *Rhizophora* disappear and then the *Laguncularia* went, leaving only *Salicornia*, *Batis* and *Avicennia*. In the Red Water, *Rhizophora* has largely disappeared, leaving *Avicennia* with *Batis maritima* and a bare salina (Plate 16, fig. 4 and text-fig. 23).



TEXT-FIG. 23. A map of Red Water Pond and sand beach after C. E. Hamshire. Symbols as in text-figs. 19 and 20.

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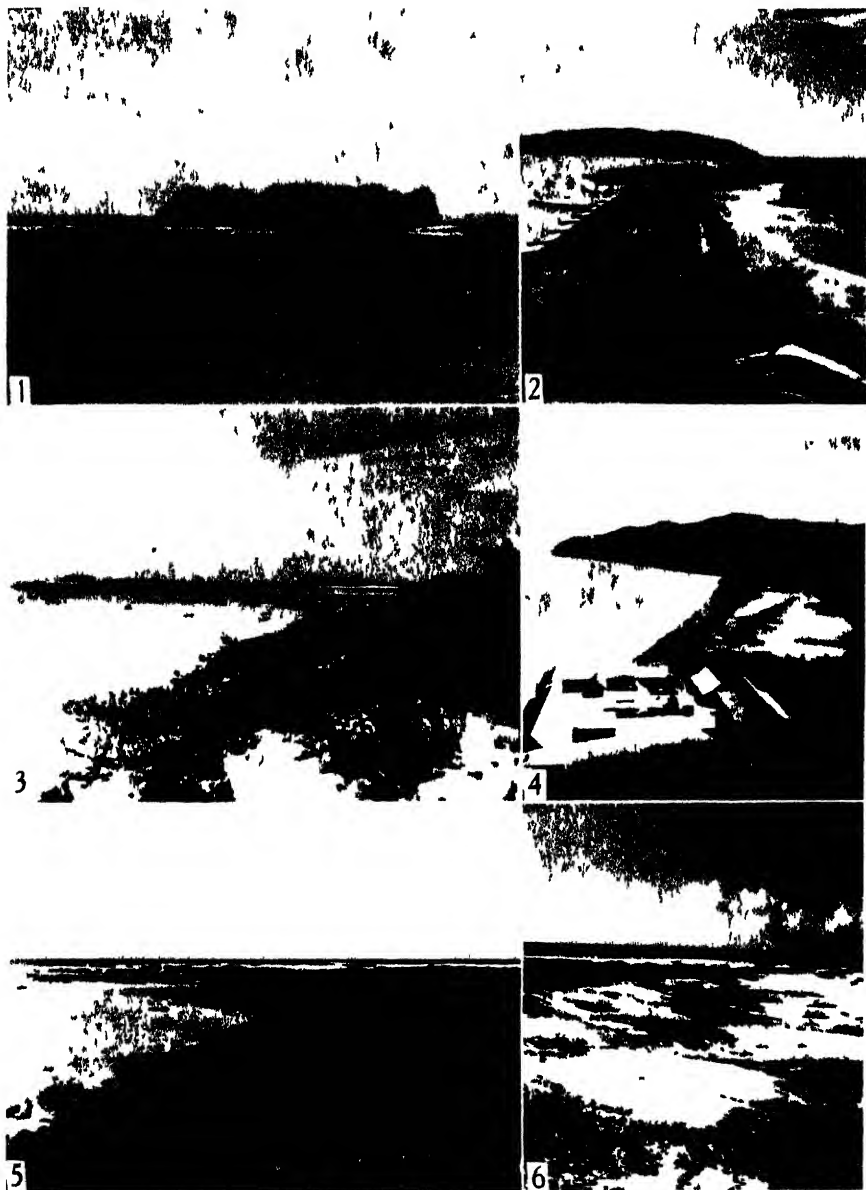
## EXPLANATION OF THE PLATES

## PLATE 16

- Fig. 1. Drunkenman's Cay. (J.A.S.)  
 Fig. 2. Looking towards Port Henderson along the Fort Augusta spit. (J.A.S.)  
 Fig. 3. Portland North and Middle cays from South Cay. (J.A.S.)  
 Fig. 4. The Lazaretto Pond. The salina is white, with the pond surrounded by mangroves on the left. (J.A.S.)  
 Fig. 5. Morant cays; *Sesuvium* and *Sporobolus* (right) on Middle Cay. (J.A.S.)  
 Fig. 6. Morant cays; *Ipomoea* on South-east Cay. (J.A.S.)

## PLATE 17

- Fig. 7. Morant cays; *Sesuvium* on promenade of South-east Cay. (J.A.S.)  
 Fig. 8. *Sesuvium*, on South-east Cay, Port Royal. (J.A.S.)  
 Fig. 9. Morant cays, bare area, North-east Cay. (J.A.S.)  
 Fig. 10. Morant cays, low dunes, North-east Cay. (J.A.S.)  
 Fig. 11. *Laguncularia* scrub South-east Cay, Port Royal. (J.A.S.)



Vegetation of the Jamaican shore line



Vegetation of the Jamaican shore line

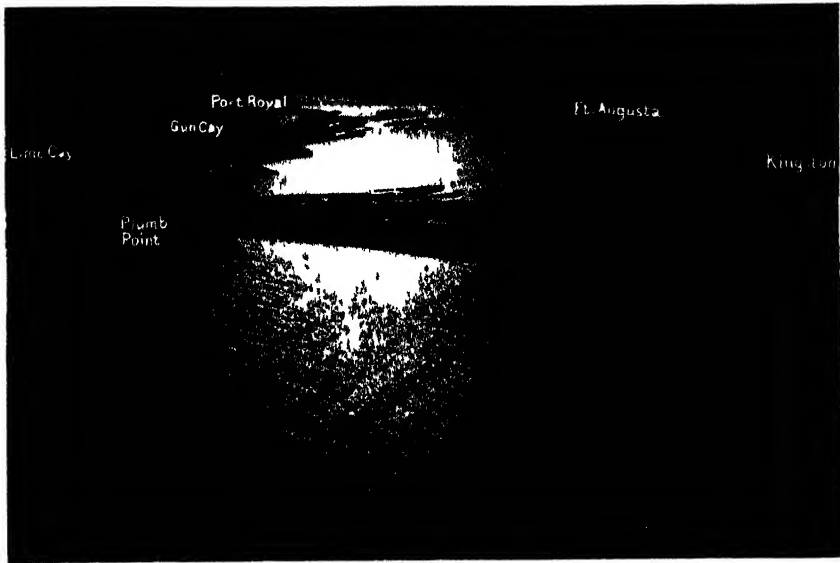


Fig. 12. Aerial view of the Palisadoes. Fort Augusta spit reaching out in background. (Gick)

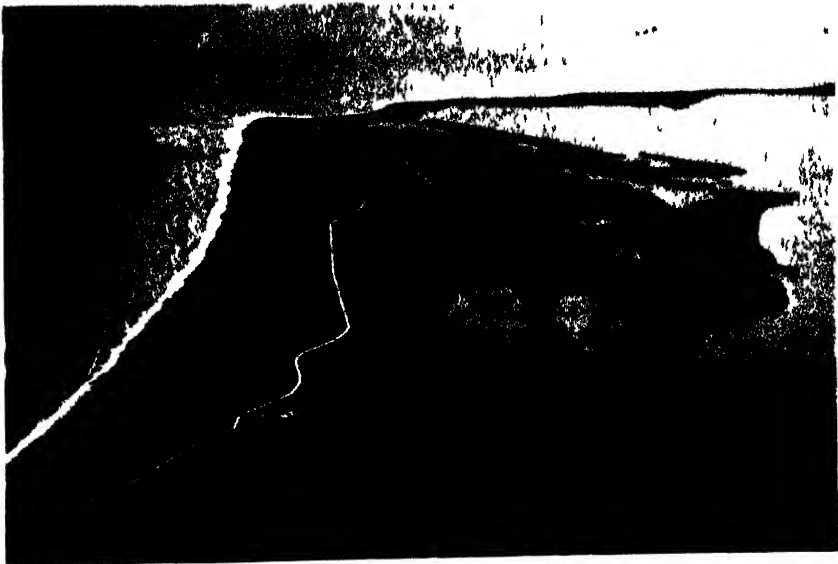
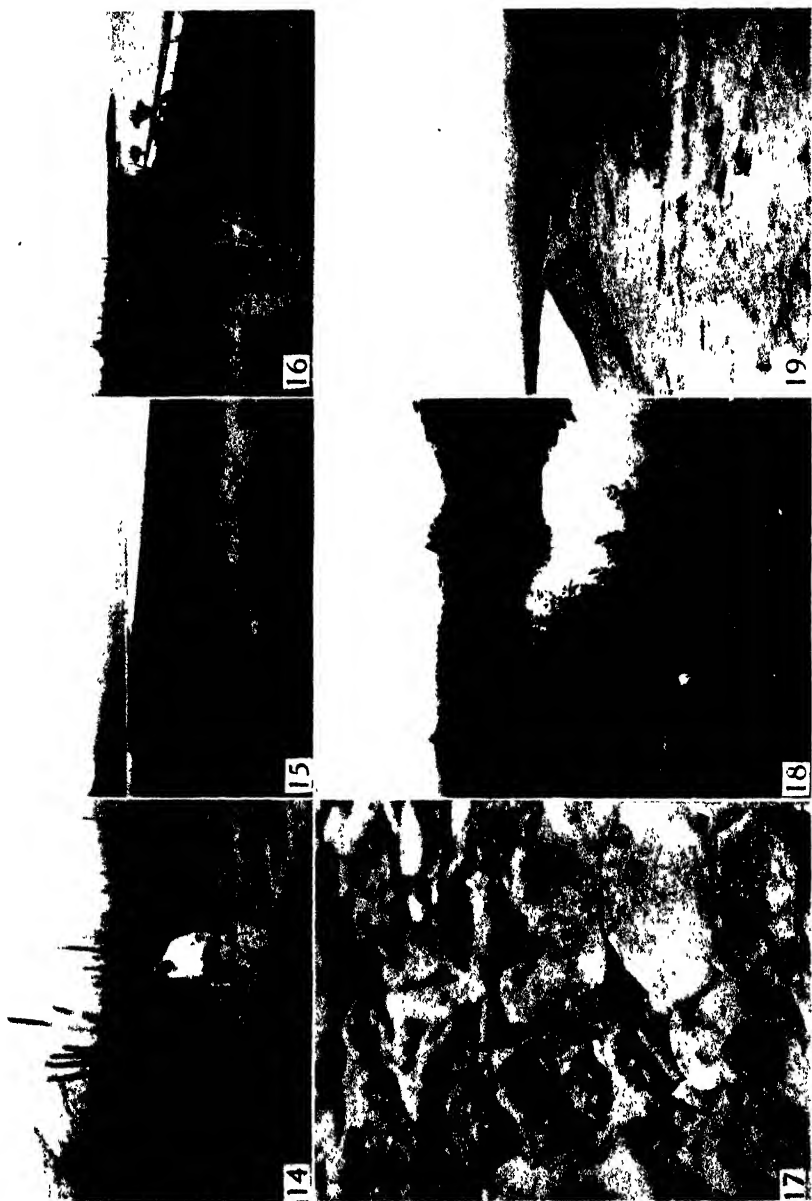


Fig. 13. Main mangrove swamp at Plumb Point, Palisadoes. (Gick)





Vegetation of the Jamaican shore line



Vegetation of the Jamaican shore line



## PLATE 18

Fig. 12. Aerial view of the Palisadoes, Fort Augusta spit reaching out in background. (Gick.)

Fig. 13. Main mangrove swamp at Plumb Point, Palisadoes. (Gick.)

## PLATE 19

Fig. 14. The Palisadoes, *Acacia* scrub. (K.R.S.)

Fig. 15. The Palisadoes, developing *Acacia* scrub. (J.A.S.)

Fig. 16. The Palisadoes, *Cereus peruvianus* climax. (J.A.S.)

Fig. 17. Drunkenman's Cay, a young *Rhizophora* seedling on the rock rampart. (V.J.C.)

Fig. 18. Rio Cobre sand bar, with young plants of *Laguncularia*, the river and (behind) *Avicennia*. (V.J.C.)

Fig. 19. Seaward edge of the Rio Cobre sand spit in Hunts Bay. (V.J.C.)

## PLATE 20

Fig. 20. The Palisadoes, *Ipomoea* and *Sporobolus*. (W.R.P.)

Fig. 21. Bare area, Fort Augusta sand spit. (V.J.C.)

Fig. 22. Wind-swept *Laguncularia* on South-east Cay, Port Royal. (A.J.L.)

Fig. 23. Transition from *Avicennia* to reed swamp (*Typha domingensis*), Kingston-Spanish Town Road. (V.J.C.)

Fig. 24. *Avicennia nitida* and *Acrostichum aureum*, Kingston-Spanish Town Road. (V.J.C.)

Fig. 25. Landward edge of the Rio Cobre sand-spit. Note the steep dip on the right due to landward movement of sand. (V.J.C. from *Geographical Journal*.)

*Addendum.* Since this paper was written several contributions on the maritime vegetation of the West Indian region have appeared.

BEARD, J. S., 1944. *Ecol. Monogr.* XIV, p. 135.

BEARD, J. S., 1944. *Ecology*, XXV, p. 127.

DAVIS, J. H., 1942. *Publ. Carneg. Inst.* no. 524, p. 113.

DAVIS, J. H., 1943. Florida Geological Survey, *Bull.* 25.

HOLDRIDGE, L. R., 1940. *Carribean Forester*, 1, p. 19.

SEIFRIZ, W., 1943. *Ecol. Monogr.* XIII, p. 377.

It is impossible to consider fully the information and conclusions of these papers in any detail. When allowance is made for local differences, the vegetational communities, whether of climax or sere, do not differ fundamentally from those described in the present paper. Davis describes much the same dune succession on the Florida Cays though Hammock Woodland is there regarded as the climax and not a *Cereus* scrub. Holdridge suggests that the composition of the Puerto Rican Mangrove woods has been materially altered by man, but there was no evidence of this in Jamaica nor is it suggested by any of the other authors. The same author also believes that salinas are due to the killing off of adult trees by a rise in salinity as a result of the greater degree of exposure (cf. p. 470 of next part).

1939 Cambridge University Expedition to Jamaica.—Part 2. A study of the environment of *Avicennia nitida* Jacq. in Jamaica. By V. J. CHAPMAN, PH.D., F.L.S.

(With 18 figures in the text)

[Read 28 October 1943]

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## 1. INTRODUCTION

*Avicennia nitida* had been selected at the conception of the 1939 expedition (Chapman, 1944) as a species which would repay an intensive autecological study. The primary reason was a desire to determine whether the pneumatophores fulfilled the same functions as those described by Troll & Dragendorff (1931) for similar organs in *Sonneratia*. The choice of species proved to be particularly happy because *Avicennia nitida* is ecologically the most important mangrove in Jamaica, and probably also in the western hemisphere, because of the huge areas it occupies.

Van Eijk (1939) has suggested that halophytes<sup>1</sup> can be divided into three categories:

(1) Plants always growing on soils with less than 0.5% sodium chloride but which have some resistance to it (halo-glyphytes).

(2) Plants growing on soils with more than 0.5% sodium chloride but with their optimal development on non-haline soils (inio-halophytes).

(3) Plants with their optimal development on soils with more than 0.5% sodium chloride (eu-halophytes).

*Avicennia* and also *Rhizophora Mangle* must be regarded as falling into category (3). *Butis maritima* and *Sesuvium Portulacastrum* probably belong to the same group, but culture experiments would be necessary before this statement could be finally accepted. *Laguncularia racemosa*, *Conocarpus erecta* and *Acrosticum aureum* can be regarded as probably belonging to group (2). At present we do not know enough about the normal conditions under which halophytes exist and still less about the optimal conditions, although in both cases the position is gradually being remedied.

Troll & Dragendorff (1931) consider that there are three factors of importance operating in the mangrove habitats.

(a) *Water content of the soil.* From observations in Jamaica (cf. below) it would seem that one of two requirements have to be fulfilled. Either the roots must be in a soil in which the water content does not descend below a definite minimum value, or else they can be in soils that may dry out considerably at certain periods but which at other fairly frequent periods are saturated through tidal action. In the first event the minimum water content will vary for the different mangrove species and should become progressively lower in the sequence *Rhizophora* → *Avicennia* → *Laguncularia* → *Conocarpus*, with perhaps very little difference between the first two.

<sup>1</sup> For a detailed discussion of halophytes see Chapman (1942).

(b) *Salt<sup>1</sup> content.* It is difficult to say to what extent salinity plays a part in determining the zonation of the New World mangroves, although there is evidence that it is an operational factor in the Old World swamps. With regard to this factor, however, it is becoming clear that the term 'salinity' has been used far too loosely in the past because the control lies not in the percentage of common salt present but in the concentration of the individual ions. Van Eijk (1939) has shown that the  $\text{Cl}^-$  ions largely control growth and degree of succulence in *Salicornia*, whereas the  $\text{Na}^+$  ions are responsible for the control of the transpiration rate. Analyses of salt-marsh soils (Chapman, 1940) for total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the sodium present have shown that there is a considerable discrepancy, and that we must therefore consider the degree of ionization in the soil and the effect of the individual ions upon the plants rather than the operation of the molecular salt. More experimental work in this direction is still required because we do not know how these ions operate in order to bring about such effects as are observed.

(c) *Oxygen content of the soil.* Both this and the water content must depend upon the pore space, and in certain types of soil this may be considerable. In the mangrove swamps the greatest pore space should be found in the peat soils (see below) with that of the mud and sand progressively lower. No measurements were made from the peat soils, but the pore space in mud from the Rio Cobre swamps was 63.66%, whilst for the sand-spit in front of the swamps the pore space was only 44.58%. The normal pore space of the soil, however, is not the only factor controlling oxygen content, and the numerous burrows of the fiddler crabs are probably of far greater importance. However, it is very doubtful whether oxygen content plays any part in determining the actual zonation although it probably limits the number of species that can grow in the swamps.

The above are by no means the only factors operating in mangrove swamps, and the present author did not confine his attention solely to these three. It has been shown in the previous part (Chapman, 1944) that winter temperature and ocean currents (macroclimate) primarily determine the general geographical spread, whilst the zonation in any given region may be affected by (a) tidal inundation or phenomena arising from it, (b) soil accretion, (c) mechanical composition of the soil (e.g. the different salt-marsh seres observable in Great Britain are probably related to the soil type (Chapman, 1941), (d) exchangeable base, and (e) behaviour of the water-table, e.g. any cyclic movements. These additional factors were therefore investigated in areas where *Avicennia nitida* was growing. The observations which are recorded in the following paragraphs apply principally to habitats in which *Avicennia* was growing, though in certain cases, of course, both *Rhizophora Mangle* and *Laguncularia racemosa* were also present. This study, however, is essentially that of the autecology of *Avicennia nitida* Jacq.

## 2. CLIMATE

A. *Rainfall.* The annual rainfall in different regions of Jamaica is primarily related to the topography, but in view of the statements that have been published about the general restriction of mangroves to rain-forest climates it is interesting to note that many of the best swamps in Jamaica are on that part of the coast (the south) with the lowest annual rainfall, 30–35 in. Another feature that should be borne in mind, because it must be considered in relation to the tidal factor, is the occurrence of rainfall maxima in May and October as shown in Table I.

TABLE I. *Average monthly rainfall totals (in inches), 1870–1929*

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
4.0	3.13	3.35	4.77	8.52	6.6	4.76	6.93	7.94	10.14	8.29	5.21

<sup>1</sup> By salt is meant sodium chloride.

B. *Humidity*. In the mangrove swamps of East Africa Walter & Steiner (1937) recorded that the average humidity never fell below 80 %, and a similar high average also obtains in Jamaica. In general, the humidity rose to very high values during the night and then fell about 10 % between 8 and 9 a.m. The following observations give some indication of the range of humidity encountered. The recording hygrothermograph unfortunately suffered dislocation in transit, and as it could not be repaired the observations had to be obtained by means of a whirling psychrometer.

24 July. 11.15 a.m. Trade wind blowing strongly. In *Avicennia* swamp behind Palisadoes.

4 in. above pneumatophores over dry soil, 81.5 %.

2 in. above pneumatophores over water, 85 %.

25 July. Gun Cay. 10.15 a.m. Strong trade wind blowing. Beneath *Avicennia* bushes, 96 %.

12 noon. Strong trade wind blowing. 5 ft. 10 in. from ground. 85 %.

26 July. Lime Cay.

7 a.m. No wind. 5 ft. 6 in. from ground. Beneath *Avicennia* near edge of Cay, 85 %.

8 a.m. No wind. 5 ft. from ground. Beneath *Avicennia* near edge of Cay, 76 %.

9 a.m. No wind. 5 ft. from water. Beneath *Avicennia* in pond, 80 %.

29 July. Up Rio Cobre. 8.45 a.m. No wind. 5 ft. from ground in pollarded swamp, 76 %.  
Lazaretto. 10.20 a.m. Strong wind. 5 ft. 6 in. from ground. Beneath *Avicennia* near pond, 77 %.

The observations for 24 and 26 July indicate the great influence of standing water on the microclimate of the swamp. This may be of considerable importance in the middle of a hot day when the tide has left a thin layer of water standing on the soil surface, e.g. the transpiration rate of the lower leaves might be retarded during the hottest part of the day when water loss would otherwise be at its greatest.

2 Sept. Near mouth of Rio Cobre. 7.15 a.m. No wind. 87 %. In swamp. Leaves covered with water.

5 Sept. Careening Cay. 9 a.m. Slight wind. Among pneumatophores, 68 %.

Careening Cay. 9 a.m. Slight wind. 3 ft. from ground, 61 %.

The observations for 5 September illustrate how rapidly the microclimate may change in a vertical direction. It is clear from these somewhat inadequate records that continuous observations on the microclimate would be of considerable importance. These results are in contrast to those of Walter & Steiner (1937) for East Africa, who concluded that the uniformity of the microclimate would have no great influence on the plants. The scanty data here provided suggest that this might not hold true for the West Indies, and that changes in microclimate may prove very important during the period of seedling establishment.

C. *Temperature*. Davis (1940) has produced some evidence from Florida to show that minimum temperatures are of primary importance because mangroves will not survive hard frosts. 27° F. apparently does not kill, but 22° F. has a distinct lethal effect, and Davis concluded that temperatures below 25° F. are fatal. Frost temperatures do not occur in Jamaica, but there are minor fluctuations; it is again worth noting, in connexion with the tidal phenomena, that the months with the hottest temperatures are June, July and August. The figures in Table II are based on observations over 36 years at Kingston.

Apart from the temperature changes of the macroclimate there are also those of the microclimate. These latter cannot be expected to have any great effect on well-established mangrove plants, but they may be of some importance for seedlings of *Avicennia* during

TABLE II

Month	Mean temp. °F.	Av. temp. 7 a.m. °F.	Av. temp. 3 p.m. °F.	Av. max. temp. °F.	Av. min. temp. °F.	Av. highest max. °F.	Av. lowest min. °F.
Jan.	75.8	69.0	82.6	86.0	67.4	89.9	63.2
Feb.	75.7	69.2	82.4	85.8	67.3	89.4	63.3
Mar.	76.5	71.1	82.7	86.0	68.1	89.4	64.4
Apr.	78.2	74.7	83.1	86.7	70.2	90.3	66.7
May	79.7	77.7	83.5	87.3	72.4	90.7	68.9
June	80.9	78.4	85.0	88.5	73.6	92.2	70.5
July	81.4	78.0	86.2	89.8	73.4	93.4	70.4
Aug.	81.0	77.0	85.5	89.8	73.5	93.1	70.5
Sept.	80.6	76.8	84.8	89.5	73.5	92.6	70.8
Oct.	79.4	75.4	84.0	88.3	72.6	92.0	69.3
Nov.	78.3	73.1	83.7	87.4	70.9	90.9	67.0
Dec.	76.8	70.6	83.0	86.6	68.8	90.1	64.7

the period of establishment and also for the algal flora. Some more work is necessary, however, before we know whether temperature can affect the establishment of floating or stranded seedlings. A few observations on soil temperature were made on the Fort Augusta spit, and these showed that there may be quite distinct fluctuations determined partly by the time of day and degree of cloudiness and partly by the type of habitat:

		15 Aug.	17 Aug.
High water, tide just covering the ground		11 a.m.	1 p.m.
Open sand salina		36.3°C.	38.5°C.
Fringe of young <i>Avicennia</i> trees		31.5°C.	35.5°C.
In glade of old trees		30.0°C.	32.8°C.
19 Aug.	Open salina	In glade of old trees	
	Surface, 33.5°C.	28.5°C.	} 10.30 a.m.
	12 cm. down, 30.5°C.	28.0°C.	
	Surface, 36.0°C.	31.5°C.	} 11.30 a.m.
	12 cm. down, 32.0°C.	31.0°C.	

D. *Evaporation*. No figures for the evaporating power of the air were obtained from the Jamaican swamps, but Davis (1940) has recorded intense evaporation from the Florida swamps. The rate in a stand of *Rhizophora Mangle* was of the order of 20.48 c.e. per diem, and in *Avicennia* glades 21.56 c.e. per diem.

E. *Light*. The amount of light penetrating the canopy will only affect seedlings and algae growing in the swamps, and unless the canopy is very dense, which occurs but rarely, there will be numerous light flecks. Walter & Steiner (1937) found that there was very little difference between the amount of light penetrating different kinds of mangroves in East Africa:

*Rhizophora mucronata*—under crown of young trees. 22–33 % of incident light.

*Avicennia marina*—under crown of old trees. 20–36 % of incident light.

*Avicennia* species in the Old World are regarded as 'light-demanders', so that they cannot regenerate even in moderate shade (Watson, 1928). In Jamaica, however, *A. nitida* was found regenerating under considerable shade in the swamps bordering the Kingston-Spanish Town Road.

The figures do not suggest that light is likely to be a limiting factor for undergrowth, and therefore the absence of ground cover must be due not to this factor but to the lack of species capable of growing under halophytic conditions and poor aeration. In parts of the Jamaican swamps where drainage is fair and where aeration is also probably



adequate one may find an undergrowth of *Batis maritima* or *Sesuvium Portulacastrum*. Daylight remains remarkably constant throughout the whole of the year, sunrise ranging from 5.30 to 6.40 a.m. and sunset from 5.50 to 6.40 p.m.

F. *Hurricanes*. These are perhaps of greater importance than might at first be supposed. The destruction of mangroves due to the operation of this factor has been recorded by Børgesen (1909) in the Danish West Indies, and Davis (1940) reports that the hurricanes of 1926, 1929 and 1935 in Florida killed all the trees in the centre of the track. It has already been suggested in the previous part (Chapman, 1944) that the area with dead trees on Salt Island might be due to hurricanes, and I was informed of one or two similar areas where the same explanation might be valid. In the case of well-established plants it is clear from the dead remains that the trees are not uprooted, and it has been suggested that they are more or less shaken to death through the stripping of the bark, buds and leaves.

### 3. TIDES AND ASSOCIATED PHENOMENA

In an account of the factors controlling mangrove zonation in Florida, Davis (1940) points out that one may find a distinct zonation in areas where there is little or no tide, and one might therefore conclude that this is an insignificant factor. Whilst this may be true, nevertheless it is also clear from the observations made in Jamaica that even with an extremely small tidal range, a change of only 1 in. in the vertical height may bring about far-reaching consequences, and hence this factor cannot be disposed of thus lightly.

The maximum rise and fall of the tides in Jamaica does not exceed 16 in., but as there are two distinct classes of tides calculations of tidal phenomena are rendered even more complex than in other places:

(a) *Diurnal tides*. When these are in operation there is only one high and low water every 24 hr.: they occur when the moon's declination is greater than 9° north or south.

(b) *Semi-diurnal tides*. This is the normal condition with two periods of high water every 24 hr.: they occur when the declination of the moon is less than 9° north or south.

In calculating the submergences a further difficulty arose because there are no tide tables for any port in Jamaica. The American Coast and Geodetic Survey use Galveston, Texas, as the reference port, whilst the British Admiralty use St Paul Island in the Gulf of St Lawrence as the reference port. This latter choice adds a further complication because St Paul Island has no diurnal tides whereas these are a conspicuous feature of the Jamaican shore. In the following calculations Galveston was therefore used as the reference port. When the comparison of the actual tide curves obtained by the expedition tide gauge was made with those calculated for Galveston and St Paul Island neither of these reference ports made a very good fit either for time or height. In the *Handbook*

TABLE III

	U.S. Coast and Geod. Surv. (calc. level) ft.	Tide chart (Expedition level) ft.
Height of max. spring tide	1.5	1.05
Height of min. neap tide	0.2	0.14
	U.S. Coast and Geod. Surv. ft.	
Maximum tidal rise	1.4	
Minimum tidal rise	0.07	
Mean range diurnal tides in Kingston Harbour	0.66	
Mean range semi-diurnal tides in Kingston Harbour	0.25	



TEXT-FIG. 1. Tide chart obtained at Port Royal, 10-12 September 1939. [Cf. text-fig. 6, p. 414, for explanatory details.]

of Jamaica it is pointed out that the tidal heights and ranges are frequently obscured by larger irregular fluctuations in ocean level which cannot be attributed to either the sun or moon. For all these reasons it would be well worth while establishing a permanent tide gauge and reference port in Jamaica for the West Indies as a whole. Bearing this somewhat unsatisfactory state of affairs in mind the general features of the tides in Jamaica are recorded in Table III. This has been prepared from the U.S. Coast and Geodetic Survey and also from the actual tide curves obtained during the expedition.

A portable tide gauge that had been used by the Great Barrier Reef Expedition (1928) was established on the wharf at Port Royal and records were obtained from 4 to 22 August when the instrument became jammed. The trouble was rectified and a further set of records was then secured from 4 to 22 September. At the same time a smaller instrument was set up over a pit in the *Avicennia* swamp on the Fort Augusta spit. This instrument gave a reliable record of those tides which flooded the swamp and so enabled the height of flooding tides to be established. There were no adequate bench marks near the swamps or at Port Royal, so that all the computations can only be approximate. Mr Lofthouse levelled a number of stations on the Fort Augusta spit using the highest drift line (which was taken as representing extreme high tide mark) as an arbitrary zero, subsequently termed 'expedition level'. The tide gauge in the swamp was levelled at the same time, and by comparing tides for any one day one could level as nearly as possible the tide gauge at Port Royal. In order to make further calculations it was essential to relate the tide curves obtained at Port Royal to the tide values given for the corresponding period at Galveston. This proved extremely difficult because of the great variability in the actual recorded tides, but eventually the correlations in Table IV were achieved. It cannot be too strongly emphasized that these must only be approximate, not only on account of the scanty data but also because of the great inherent difficulties (text-fig. 1). The correlations are given, however, because there is no other way of arriving at any figures for submergence, and although it is not claimed that the computed submergences represent absolute values, nevertheless they do demonstrate the great changes that occur with every few inches rise or fall of level; this is the main point that the author wishes to make.

The next step in the process was to determine, so far as possible, the most significant levels in relation to the vegetation; here it is to be regretted that the sudden departure due to the war upset plans for a more extensive levelling survey. On the Fort Augusta spit the more important levels are given in Table V, but they are not necessarily those of the Jamaican swamps as a whole.

Once these correlations were established it then became possible to use the 1939 tide tables for Galveston in order to calculate certain tidal phenomena over a period of one year. The results of these calculations are shown in Table VI.

(a) *Submergences per annum.* (This refers to flooding of the soil and it also involves inundation of the pneumatophores.)

It will be seen that there is a very considerable range and that the lower levels in the swamps will be continually submerged. At the higher levels it may be noted that the month with the greatest number of

TABLE IV

Height of tide (Galveston level) ft.	Height of tide (Kingston level, 0.7 of Galveston level) ft.	Corresponding Expedition level ft.	Corresponding level as marked on tide charts ft.
1.6	—	—0.20	1.02
1.5	1.05	—0.27	0.95
1.4	0.98	—0.34	0.88
1.3	0.91	—0.41	0.81
1.2	0.84	—0.48	0.74
1.1	0.77	—0.55	0.67
1.0	0.70	—0.62	0.60
0.9	0.63	—0.69	0.53
0.8	0.56	—0.76	0.46
0.7	0.49	—0.83	0.39
0.6	0.42	—0.90	0.32
0.5	0.35	—0.97	0.25
0.4	0.28	—1.04	0.19
0.3	0.21	—1.11	0.12
0.2	0.14	—1.18	0.05

TABLE V

	Expedition level ft.	Chart level ft.	U.S. Coast and Geod. Surv. Calc. level ft.
Average level of upper boundary of <i>Laguncularia</i>	—0.22	1.00	1.57
Dead <i>Avicennia</i> bushes on salina	—0.36	0.86	1.37
Centre of salina	—0.47	0.75	1.21
Average level of upper boundary of <i>Avicennia</i>	—0.52	0.70	1.14
* Average level of <i>Avicennia</i> swamp	—0.73	0.49	0.84
Average level of boundary between <i>Rhizophora</i> and <i>Avicennia</i>	—0.90	0.32	0.60

TABLE VI

Galveston level	Vegetation	No. of submer- gences per annum	Month of greatest submer- gence	Max. period non-tidal exposure days	Date of max. period	Watson's Inunda- tion Class (1928)
1.57	<i>Laguncularia/Conocarpus</i> boundary	4	Oct.	339	Nov.—Sept.	5
1.37	Dead bushes on salina	89	Oct.	157	Mid. Nov.— mid. Apr.	5
1.21	Centre of salina	150	Oct.	125	Dec.—Mar.	4
1.14	<i>Avicennia/Laguncularia</i> boundary	213	Oct.	110	Mid. Dec.— Mar.	4
0.84	Average level, <i>Avicennia</i> swamp	432	Sept.	52	Jan.—Feb.	3
0.60	<i>Rhizophora/Avicennia</i> boundary	524	Aug.	10	Jan.	3
Below 0.6	<i>Rhizophora</i>	530— 760+	—	0–10	—	1, 2

submergences is also the month with the heaviest rainfall. If the reverse had been the case this factor would have been of more significance.

(b) *Non-tidal exposure*. This term is used for periods of two or more whole days during which no tide covers the area. It is at once obvious that the mangrove swamps in Jamaica are by no means flooded continually, and that there are considerable periods when the vegetation is dependent upon rain water or water draining in laterally from the creeks and rivers. One is commonly led to regard mangrove swamps as forests in which the tide enters every day, but these calculations should go far towards dispelling this impression. The lower boundary of the *Rhizophora* zone will, of course, have no periods of non-tidal exposure. It is worth noting that these long periods occur during winter and early spring at a time when the temperatures are at their lowest, and therefore when evaporation from the ground will not be as excessive as it would be between June and August.

(c) *Inundation classes*. It has been suggested previously (Chapman, 1944) that the small number of species and insignificant tidal range render valueless any concept of inundation classes. When we come to analyse the figures of Table VI and their importance we must consider both the adults and the seedlings, and it is the latter which are the more susceptible to any changes. In view of the great range in the number of submergences it is possible that the upper limits of adult *Rhizophora* and *Avicennia* may be partially determined by this factor; non-tidal exposure might be an additional factor for *Rhizophora*, though not for any other species. When we come to consider the seedlings, however, the tidal phenomena may be of sufficient importance to determine the adult zonation because this is naturally dependent upon the successful establishment of the seedlings. Davis has already suggested that exposure and drying between tides may harm young plants, but the figures for non-tidal exposure indicate that this is a far more serious factor. In the *Avicennia* swamps there may be a period of from 10 to 110 days with no tidal flooding, and seedlings just starting growth at the beginning of any of the longer periods would be killed. Seedlings washed up to still higher levels would stand an even greater chance of encountering a long period of non-tidal exposure. It may be suggested therefore that the zonation might well be controlled by the length of non-tidal exposure which the seedlings and the young plants are able to tolerate. The proof of this contention must, of course, lie in experimental work designed to show the degree of exposure the seedlings will endure.

In an investigation of the salt marshes on the Welsh coast, Wiehe (1938) showed that the occurrence of a flooding tide at the time when young seedlings of *Salicornia* were in the process of being established could produce very great effects on the distribution of the adult plants. The tide operates through the purely mechanical pulling up of the seedlings, and a similar phenomenon is to be seen in the Jamaican swamps. When a seedling of *Rhizophora* or *Avicennia* lodges on a sand shoal the tide may frequently uproot the seedling before it is properly established. Observations made at the salina on the Fort Augusta spit suggested that seedlings of *Avicennia* are particularly susceptible to this mechanical effect. The first adequate anchoring root has not reached sufficient length to be efficient until a period of 7 days has elapsed from the time the seedling emerges from the testa,<sup>1</sup> and during this period a tide may easily cause it to be uprooted or washed away. The seedlings of *Rhizophora*, which drop down and stick into the muddy soil, are probably not only sufficiently weighted against removal but are also securely fixed into the soil so long as it is not too compact, and the tide can only remove these seedlings when they are thrown up on a sand shoal or beach. *Laguncularia* is not normally viviparous but the seeds will be subject to removal by the tides, and it may be this factor which prevents the species from descending lower on the shore. It is suggested that future investigators might well study the zonation in mangrove swamps from the point of view of seedling establishment.

<sup>1</sup> Details will be described in another part.

(d) *Hours of submergence.* Apart from the calculations above, which are based on the Galveston tide tables, the actual curves on the tide charts (text-fig. 1) were used in order to provide an indication of the hours during which the soil was submerged daily. For this purpose two periods were selected: *Period A*, 7–20 August; *Period B*, 4–17 September (Table VII). These figures, which are in hours, unless otherwise stated, do not do more than give an indication of the length of submergence any level is likely to undergo during the month; hence no attempt has been made to draw any conclusions from them.

TABLE VII

Chart levels	-0.86'			-0.75'			-0.70'		
	Tot.	Av. week	Av. day	Tot.	Av. week	Av. day	Tot.	Av. week	Av. day
Period A	—	—	—	14½	7½	1 hr. 3 m.	49½	24½	3½
Period B	3½	1½	15 m.	12½	6½	48 m.	23½	11½	1½

Chart levels	-0.49'			-0.32'		
	Tot.	Av. week	Av. day	Tot.	Av. week	Av. day
Period A	116½	58½	8½	194½	97½	13 hr. 54 m.
Period B	82½	41½	5 hr. 52 m.	145½	72½	10 hr. 22 m.

#### 4. ACCRETION

A bag of coloured Alum Bay sand was taken out with the intention of spreading it on the swamps and thus obtaining an estimate of the rate of accretion in a manner similar to that successfully carried out by Steers (1938), Chapman (1938*b*), Neilsen (1935) and Richards (1934) for various salt marshes. The sand was duly laid down, but it rapidly disappeared from the peat and mud soils and only persisted on the open salina of the Fort Augusta spit. Here the rate of accretion was not great, but the sand did become covered by mud over most of the line, though the covering was hardly of a thickness that could be measured accurately. It would seem that some other method of measuring accretion on peat and mud soils will have to be adopted since the Alum Bay sand disappears.

A certain amount of work (Drew, 1914) has been carried out on the deposition of the calcareous marine muds of Florida and the Bahamas, and there is evidence that the *Bacterium calcis* is capable of precipitating chalk from sea water in these regions; this organism has also been recorded from Jamaican waters. It will be observed later (cf. p. 463) that the mangrove muds and peats of Jamaica do not, on the whole, have a high percentage of chalk, so that the activities of this bacterium cannot be of great importance. The mangrove muds are particularly referred to here because Bavendamm (1931) has reported that the mangrove swamps of the Bahamas are regions where this bacterium may be especially active. More recent work (Revelle, 1934; Troll & Dragendorff, 1931) has tended to lay emphasis on physico-chemical precipitation as being the most important factor; this functions either through variations of pH or else through the direct coagulating power of sea water.

#### 5. SOILS

Soil samples were collected from every type of habitat occupied by *Avicennia nitida*, and the general conclusion is that this species is capable of tolerating a considerable

range of soil conditions, not only physical but chemical. Analyses of these soils showed that they could be divided into four categories:

Jamaica	Corresponding types in Florida
(a) <i>Halimeda</i> sands	Calcareous sands
(b) Siliceous sands	Siliceous sands
(c) Muds and sandy muds	Calcareous marl muds
(d) Peat, either fibrous or plastic	Peat (fibrous or plastic)

Fibrous peat came from Careening Cay and the Palisadoes, whereas the peat of the Fort Augusta spit was of the plastic variety, i.e. the particles are fine and the soil becomes hard and dense when dry. Compared with the mangrove soils of Florida there is a much lower percentage of chalk in the mud and peat soils, but this is perhaps due to the greater abundance or activity of *Bacterium calcis* in Florida. The *Halimeda* sand does not appear to exist in Florida and is replaced there by a calcareous sand. The *Halimeda* sand is calcareous, but as it is composed very largely of fragments of the green alga of this name it was thought desirable to treat it separately. Some counts were made of the composition of the fraction of *Halimeda* sand not passing the 2 mm. sieve with the results shown in Table VIII.

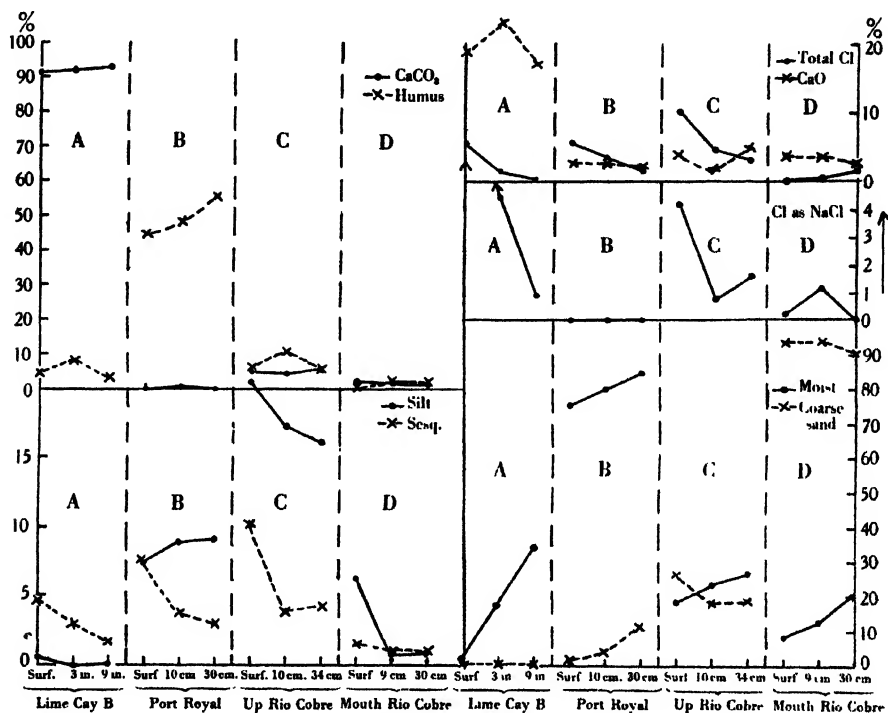
TABLE VIII

	Lime Cay		Careening Cay	
	No. of pieces	%	No. of pieces	%
Mineral matter	43	7.5	8	0.9
Shell fragments	41	7.4	33	3.5
Crab fragments	1	0.2	1	0.1
<i>Halimeda</i> fragments	392	71.3	864	91.0
Coralline red algae	17	3.1	3	0.3
Echinoderm and sponges	5	1.0	2	0.2
Coral fragments	54	9.5	38	4.0
		100		100

The soil samples were generally collected at three different levels, (a) surface, (b) 10 cm., (c) 20–30 cm. Changes in the surface layers provide an indication of the conditions under which any algae exist; the 10 cm. layer was that in which many of the absorbing roots are to be found, whilst the cable and anchoring roots<sup>1</sup> occur in the lowest level. As soon as the soils were brought back to the laboratory at Hope the moisture content of the wet soil was determined by heating in an oven to 105°C. The remainder of the sample was air-dried and packed into a bag for transit to England. Although in the course of this journey some soil might have passed from one bag to another, intermingling would only have taken place in the outer layers, and when the bags were emptied much of this material remained adhering to the bags and so was not used. In the laboratory at Cambridge each sample was analysed (a) mechanically and then for (b) pH by the Kuhn method, (c) carbonate by Collins's calcimeter, (d) loss on ignition (=humus, after allowance for CO<sub>2</sub> and water), (e) total chlorides by changes in electro-potential, (f) sodium (from this figure the chloride that could be present as sodium chloride was calculated) by zinc uranyl acetate, (g) exchangeable base in the form of CaO by means of ammonium oxalate and back titration with standard potassium permanganate. The high proportion of carbonate and humus in some of the soils interfered with the mechanical analyses, and so these results have not the accuracy that they should otherwise have.

<sup>1</sup> These will be described in another part.

Before considering these soil types in detail attention may be drawn to the broad general features which distinguish them. These are set out graphically in text-fig. 2, in which the *Halimeda* sands are type A, the peat soils type B, the mud soils type C and the siliceous sands type D. The *Halimeda* sand is, of course, very high in carbonate content, whilst the other three types are low, that of the mud soils being slightly higher



TEXT-FIG. 2. The essential differences between the four soil types: A, *Halimeda* sand; B, peat soil; C, mud soil and D, siliceous sand.

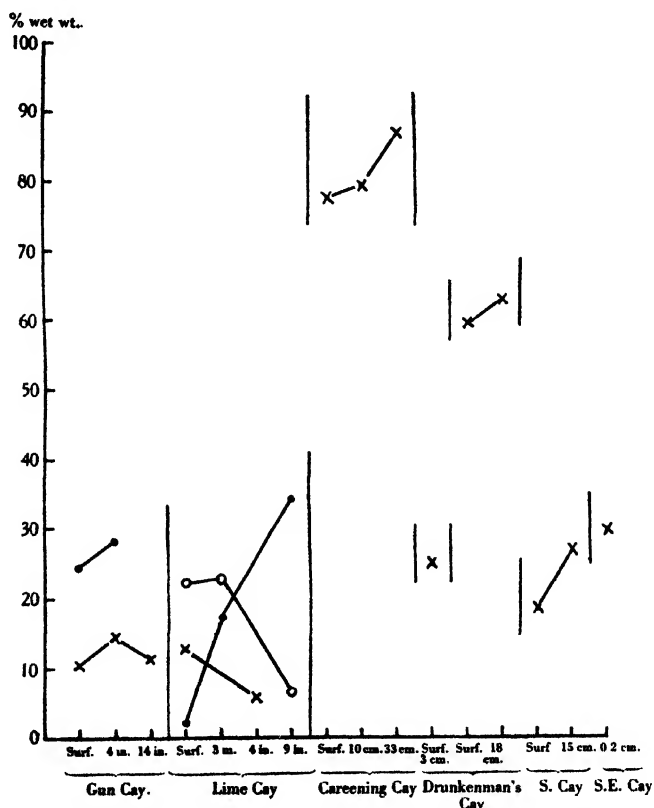
than the other two. The peat soils are characterized by an almost complete absence of any carbonate. The *Halimeda* sand and the mud soils contain approximately the same quantity of humus (5–10%), whilst the peat soils contain the most and the siliceous sands the least (1–3%). The silt fraction increases in the sequence A, D, B, C, and with the exception of the peat soils the percentage of silt decreases with increasing depth of soil. The percentage of sesquioxide is lowest in the siliceous sands (D) and then increases from types A to C: this fraction also decreases with increasing depth of soil. Turning to yet other features, the *Halimeda* sand is very high in exchangeable base, whereas there is little distinction between the other three types. The total chloride is lowest in the sandy soils and highest in the muds, but the differences are not great and there is a general tendency throughout for the percentage to fall with increasing depth of soil. The most striking feature about the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$  (assuming that nearly all the  $\text{Na}^+$  ions have an equivalent of chloride<sup>1</sup>) is that generally there are not sufficient  $\text{Na}^+$  ions to account for all the total chloride recorded, although they do account for a great proportion. An extreme example was the available  $\text{Na}^+$  of the peat soils: this was

<sup>1</sup> This assumption is probably justified in a maritime soil where the proportion of sodium chloride to other salts is extremely high.

commonly 0%. Such a result does not mean that the equivalent chloride ions are not available, but it does indicate that in the peat soils the  $\text{Na}^+$  ions are firmly held and cannot be extracted by the usual leaching methods. This fact further emphasizes the great significance of ionization and the independent behaviour of the individual ions.<sup>1</sup> Text-fig. 2 shows that there is a sharp distinction between the moisture contents of the different types. The peat soils have a much higher water percentage than the other three, and it will also be observed that the water content increases with increasing depth of soil. The coarse sand fraction in the different types is very distinctive, as it increases from very low values in the *Halimeda* sand to very high values in the siliceous sand.

(a) *Halimeda* sands

The analyses for these samples are set out in Table IX, but it is not proposed to discuss them in any great detail as the figures speak for themselves. Certain features, however, are worthy of comment. It is clear that the pH can be of little significance



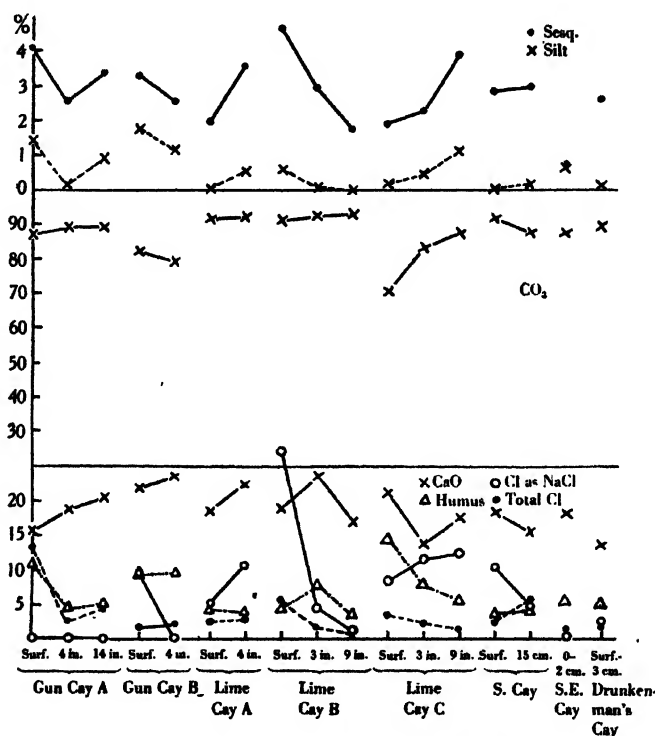
TEXT-FIG. 3. Percentage moisture in the *Halimeda* sands.

because it only ranges from 7.6 to 8.0. There is a very high proportion of the soil which does not pass the 2 mm. sieve, whilst it will be noted that the coarse sand, fine sand, clay and silt fractions are all low. The moisture contents of these sands, which all came from the cays, are depicted graphically in text-fig. 3: it will be observed that they are

<sup>1</sup> For more detailed discussion of this point see Chapman (1942).



low and generally show an increase with depth up to 4 in. or 10 cm. and commonly increase still further with depth, but this is to be expected because the water-table is approached. The high values at Careening Cay and for the surface and 18 cm. of Drunkenman's Cay are due to the fact that these are partial peat soils and in certain respects belong to the next category. Some of the other analyses are set out graphically in text-fig. 4, where it can be seen that there is a general resemblance between the curves for silt, sesquioxide and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , although this does not necessarily mean that there is an actual correlation between all three. The sesquioxide curves do not show much variation though they have a general tendency to fall between the surface and 4 in. and then to increase once more, although an exception to this behaviour



TEXT-FIG. 4. Chemical analyses of *Halimeda* sands.

was recorded at Lime Cay B. The silt curves are very irregular and exhibit no general trends, but those for carbonate do have a tendency for the percentage to increase slightly with depth. This is probably due to a leaching factor and may have an important bearing on beach rock formation. There is no obvious relationship between the total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , and both vary in their behaviour with increasing depth. The percentage of exchangeable base also shows considerable variation, with a slight tendency for a general increase during the first few inches down. The humic contents are fairly consistent throughout, and in all cases there is a tendency to decrease with depth. This is because the bulk of the humus is due to dried leaves, fruits and stems of the mangroves, and the greatest accumulation of these is on the surface: also they are not the type of material that readily decomposes and is washed down into the soil.

TABLE IX

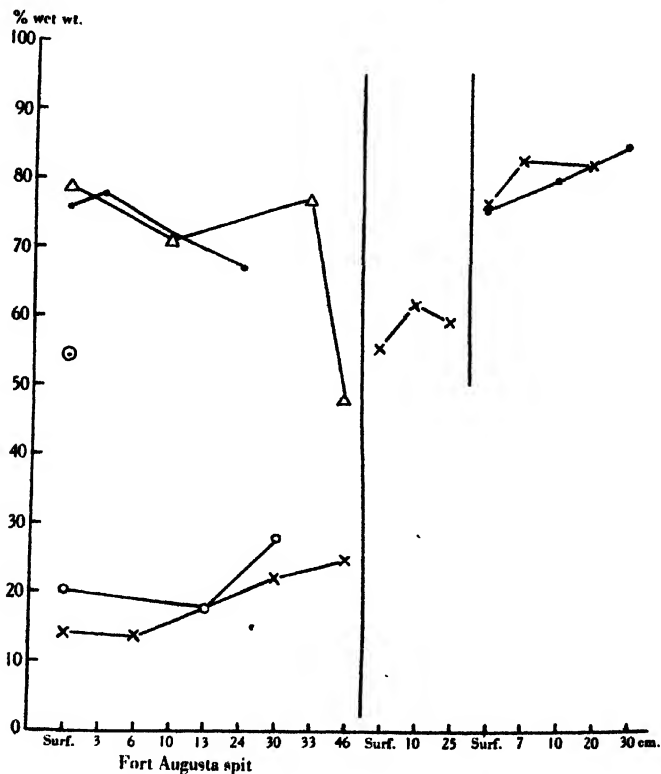
Site	No.	Soil not passing 3 mm.	Soil not passing 2 mm.	Soil passing 2 mm.	Moisture		pH	CO <sub>2</sub>	Humus	Coarse sand	Fine sand	Clay	Silt	Sesqui-oxide	Loss on solution	Cl (total)	Exch. CaO
					Wet wt.	Air dry											
Surface, Gun Cay A	1	45.7	20.8	33.5	10.24	4.56	7.6	80.7	10.72	0.62	0.37	0.82	1.40	4.04	+13.11	13.37	15.4
4 in., Gun Cay A	2	16.2	30.35	63.45	11.33	1.07	7.7	80.1	4.51	0.20	0.12	0.57	0.15	2.54	+5.4	2.44	18.67
14 in., Gun Cay A	3	22.25	17.89	30.86	11.27	0.88	7.7	80.3	4.80	0.55	0.12	0.0	0.00	3.32	+0.33	4.38	20.3
Surface, Gun Cay B	4	20.8	17.8	65.9	11.37	1.12	7.6	82.5	9.1	0.26	0.38	0.47	1.73	3.26	+1.1	1.66	21.03
4 in. water-table, Gun Cay B	5	18.52	13.10	68.17	28.30	1.65	7.7	70.36	9.63	0.20	0.34	1.4	1.15	2.55	+4.62	1.91	22.34
Surface, Lime Cay A	6	21.7	11.5	66.6	12.83	0.11	8.0	91.8	1.20	0.00	0.02	0.0	0.0	1.91	+1.45	2.45	18.31
4 in., Lime Cay A	7	24.0	34.9	93.2	5.73	0.27	7.7	92.1	3.21	0.22	0.05	0.0	0.0	3.59	+1.84	2.64	22.58
Surface, Lime Cay B	8	23.3	29.7	95.0	2.0	0.41	7.7	91.6	7.73	0.19	0.11	0.5	0.55	4.68	+2.8	5.38	18.98
3 in., Lime Cay B	9	11.0	12.0	79.1	31.42	1.45	8.0	92.1	1.84	0.17	0.11	1.07	0.0	2.94	+0.0	1.08	23.60
9 in., Lime Cay B	10	11.0	26.31	49.82	31.42	0.57	7.6	92.9	3.31	0.22	0.03	0.30	0.0	1.74	0.93	0.38	17.09
Surface, Lime Cay C	11	27.87	11.1	65.2	22.16	2.70	7.7	70.15	1.2	5.1	0.82	0.47	0.13	1.91	5.02	3.46	21.11
3 in., Lime Cay C	12	13.8	10.6	69.6	22.76	1.46	7.7	89.4	7.08	0.33	0.16	0.62	0.43	2.26	3.35	2.07	13.96
9 in., Lime Cay C	13	12.3	11.9	72.8	6.96	1.11	7.7	87.8	5.55	0.20	0.16	0.0	1.10	3.61	0.11	1.34	17.43
Surface, South Cay	14	23.5	21.2	55.3	18.51	0.68	8.0	91.66	3.68	0.11	0.12	1.35	0.0	2.67	+0.70	2.06	18.09
Surface, South Cay	15	18.2	22.4	39.1	27.08	3.71	8.0	87.18	1.89	0.33	0.20	0.99	0.12	2.98	+0.10	5.87	15.45
0-3 cm., South-east Cay	86	22.7	8.5	68.8	29.88	1.24	7.7	87.72	5.35	0.27	0.21	0.21	0.87	0.70	+0.20	1.13	18.12
Surf.—3 cm., Drunkenman's Cay	79	6.4	7.5	86.1	25.16	0.36	7.7	89.4	4.92	0.46	0.06	0.85	0.10	2.59	+1.04	1.54	13.66

TABLE X

Site	No.	Soil not passing 3 mm.	Soil not passing 2 mm.	Soil passing 2 mm.	Moisture		pH	CO <sub>2</sub>	Humus	Coarse sand	Fine sand	Clay	Silt	Sesqui-oxide	Loss on solution	Cl (total)	Exch. CaO
					Wet wt.	Air dry											
Surface peak, Fort Augusta 1	40	5.7	0.7	93.6	75.75	5.95	6.4	0.22	36.46	17.25	10.08	13.70	24.36	4.88	+2.28	2.14	3.23
3 in., Fort Augusta 1	39	4.5	0.0	95.5	67.85	6.21	6.7	0.17	31.63	14.50	16.28	23.23	7.27	2.89	+5.4	2.33	3.27
2 ft., Fort Augusta 1	41	0.9	0.0	99.1	67.13	5.88	6.0	0.2	21.79	3.56	10.91	54.7	25.04	4.66	+4.01	3.63	4.4
Surface, Carreening Cay	51	19.4	0.0	80.6	77.76	16.38	6.4	0.0	17.57	3.84	1.13	18.3	6.64	0.26	9.54	3.06	2.60
10 cm., Carreening Cay	61	4.38	0.0	93.62	79.51	16.38	6.6	0.2	48.38	11.3	0.65	13.71	5.66	0.15	0.72	3.58	3.62
33 cm., Carreening Cay	62	4.9	1.3	93.8	87.02	12.64	6.0	0.0	51.81	8.73	11.05	12.6	6.78	1.71	+5.04	2.02	3.45
Surface, Gallion Harbour	58	2.8	0.3	96.9	55.05	5.96	7.4	1.87	19.36	3.4	27.21	19.4	6.5	7.55	+7.64	5.92	2.49
10 cm., Gallion Harbour	59	3.4	0.3	96.3	61.63	6.18	6.8	0.0	22.53	3.49	20.29	24.0	9.8	5.0	5.91	4.50	2.65
55 cm., Gallion Harbour	60	2.7	0.0	97.3	59.28	4.25	7.0	0.0	19.21	3.67	27.84	48.0	24.3	2.38	+5.77	3.24	3.11
Surface, Aerodrome	63	27.7	0.4	71.9	76.76	6.6	6.6	0.0	15.08	13.47	7.43	8.97	5.30	6.35	+3.62	3.62	2.93
7 cm., Aerodrome	67	1.8	0.0	98.2	82.45	10.73	6.5	0.0	56.28	7.56	2.02	16.31	6.8	3.3	+3.02	4.41	3.92
20 cm., Aerodrome	66	1.8	0.0	98.2	82.04	10.81	6.9	0.0	56.28	7.56	2.02	16.31	6.8	3.3	+3.02	4.41	3.92
Surface, Port Royal	71	1.2	0.0	98.4	75.32	9.73	6.6	0.0	44.12	1.66	4.38	16.2	7.1	1.59	+6.42	3.44	2.74
10 cm., Port Royal	72	11.9	0.0	88.1	79.08	11.73	6.6	0.0	44.12	1.66	4.38	16.2	7.1	1.59	+6.42	3.44	2.74
30 cm., Port Royal	73	7.7	1.3	91.0	81.18	11.65	6.6	0.0	44.12	1.66	4.38	16.2	7.1	1.59	+6.42	3.44	2.74
Surface, Fort Augusta 2	53	1.2	0.0	98.5	78.86	7.59	6.8	0.0	55.34	11.2	2.53	16.44	5.90	2.82	+0.00	3.54	2.6
10 cm., Fort Augusta 2	54	1.5	0.0	98.5	77.27	8.48	6.6	0.0	55.34	11.2	2.53	16.44	5.90	2.82	+0.00	3.54	2.6
33 cm., Fort Augusta 2	55	1.37	0.0	98.63	79.76	8.48	6.6	0.0	35.13	9.99	6.50	12.74	41.9	4.64	+16.55	4.24	2.96
Basal blue mud, Fort Augusta 2	56	4.1	0.0	85.9	47.5	6.78	6.6	0.0	32.17	9.99	6.50	12.74	41.9	4.64	+16.55	4.24	2.96
Mad foreshore, Rio Cobre	42	0.0	0.0	100.0	83.79	4.63	7.6	3.85	11.26	0.46	13.26	37.92	36.78	4.85	+0.37	6.45	4.57
0-3 in., Fresh River	50	0.1	0.2	99.7	39.1	2.28	7.6	0.96	5.42	60.1	4.91	12.95	11.8	3.52	+1.94	0.77	4.21

(b) *Peat soils*

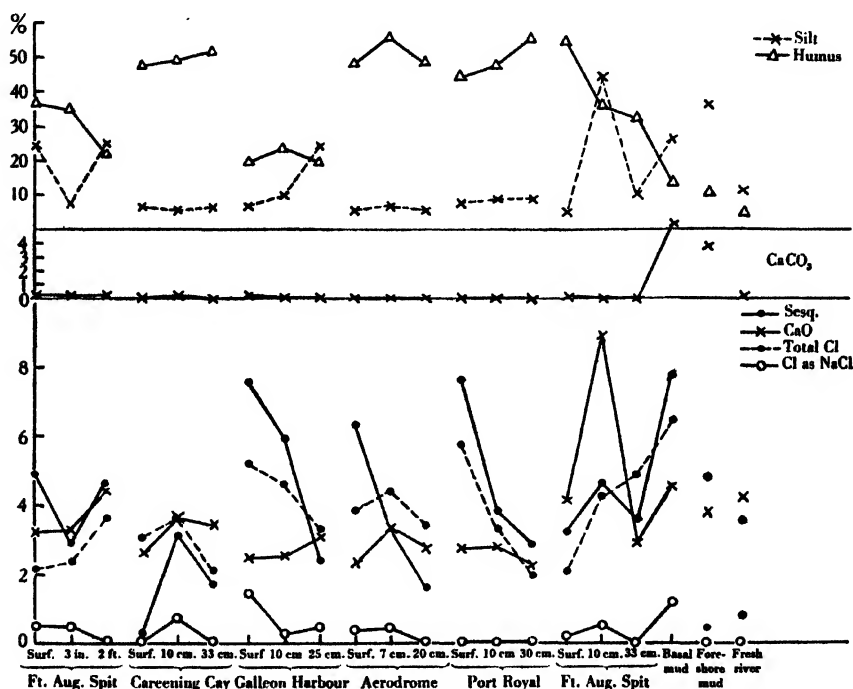
The analyses for these soils are set out in Table X: also included in this table is an isolated sample from the Fresh River and some mud from the seaward edge of the sand-spit in Hunts Bay. This latter is a sample of old mangrove mud over which the sand-bar has been pushed by wave action. The figures for the mechanical analyses of these soils have to be regarded with some caution, because the high humic content interfered considerably with the analysis (cf. the figures for the loss on solution). Although these are peat soils the pH is not abnormally acid and they are really neutral



TEXT-FIG. 5. Percentage moisture of the peat soils.

peats: the lowest pH values were recorded from the greatest depths, e.g. 2 ft. Fort Augusta 1; 33 cm. Careening Cay; 30 cm. Port Royal. Similar neutral values of 7-8.1 were recorded by Davis (1940) from wet peats in Florida, although the pH of the dry peat was lower and ranged from 4.5 to 6.5. This suggests that the alkalinity is primarily determined by the environment in which it is formed and exists. A very high proportion of the peat soils passes the 2 mm. sieve and the residue is composed principally of macroscopic plant remains. The clay fraction tends to be the highest, but there is no great variation in any of the figures. The moisture contents, based on fresh weight, are shown in text-fig. 5, and it will be observed that they are very high because of the spongy character of the peat. There is a tendency for the moisture content to increase with depth. It would seem that these soils contain considerably more moisture than do the peat soils of Florida; an average moisture content (oven dried) of 198 % is reported

by Davis (1940) for Florida, whereas the figure for the Jamaican peat soils on the same basis is 350 %. Text-fig. 6 shows graphically the results for other items in the analyses: it will be noted that the proportion of silt varies, though it may be quite high, and that there is also a tendency for it to increase with depth. The percentage of humus is generally high but fluctuates considerably, and its range from 20 to 55 % compares with the range of 54–72 % (loss on ignition) for the Floridan peats. The carbonate is remarkable because of the very low values or its complete absence, so that these soils are the very opposite to the *Halimeda* sands in respect of this character. The peat soils of Florida contained more carbonate, and though they ranged from 0.28 to 23.13 % the average value was 7.1 %, so that there is active carbonate deposition in the mangrove swamps of Florida which is not to be found in these particular Jamaican swamps. The

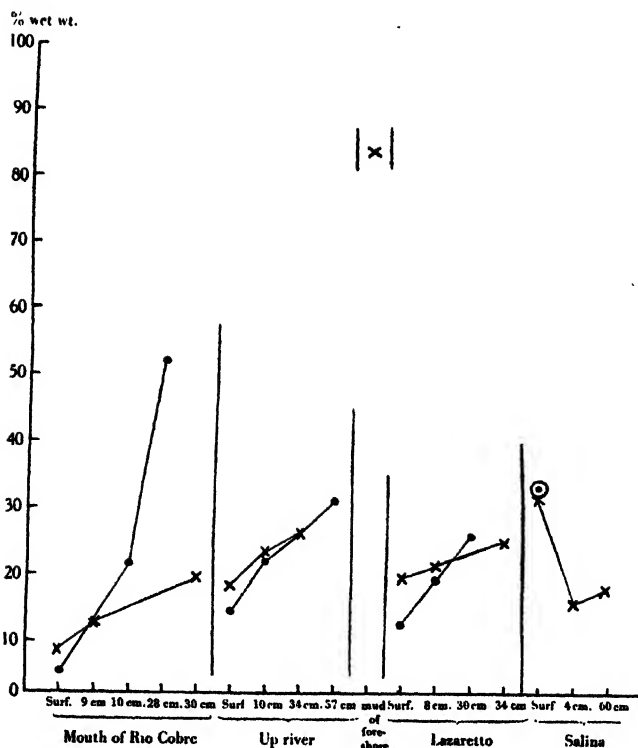


TEXT-FIG. 6. Chemical analyses of the peat soils.

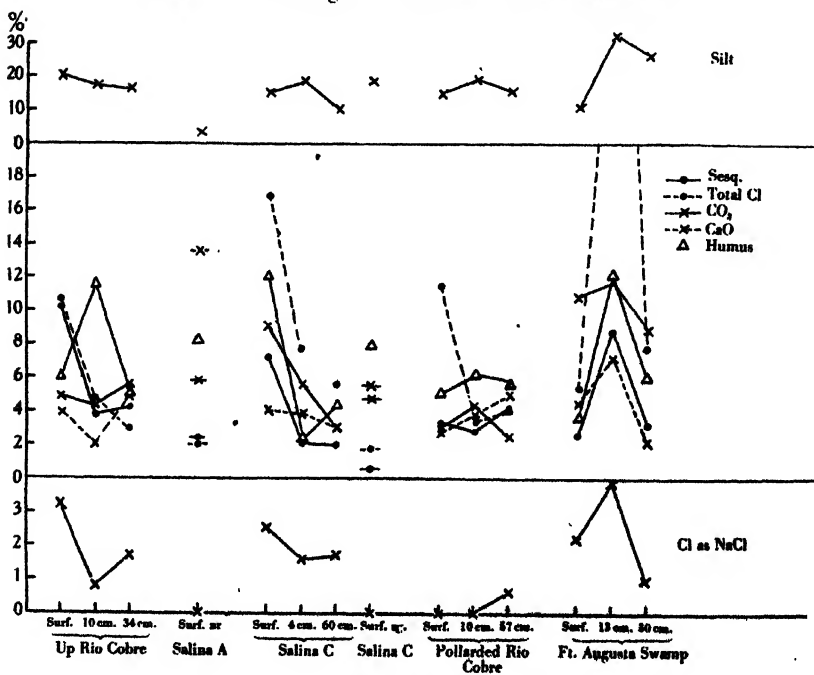
sesquioxide percentages are high and there is also a tendency for them to decrease with increasing depth of soil. As in the *Halimeda* sands there is no correlation between total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ ; furthermore, the latter forms an extremely small proportion of the total chloride. There does, however, appear to be some correlation between the exchangeable base and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , but this may be only a coincidence. We need to know much more about the behaviour of the different ions in a soil of this category before we really understand the relation between such a soil type and the plants which grow in it.

### (c) *Muds and sandy muds*

The analyses of these samples are set out in Table XI, where it will be observed that most of the soil passes the 2 mm. sieve and also that there is little or no range in pH. The coarse and fine sand fractions are not so large as those of the next group, but the



TEXT-FIG. 7. Percentage moisture of muds and siliceous sands.



TEXT-FIG. 8. Chemical analyses of mud soils.

silt and clay fractions are considerable. The moisture contents of this and the succeeding group are set out in text-fig. 7 and hardly call for comment, except to point out the great increase with depth as the water-table is approached. Again in comparison with the marl muds of Florida it seems that the moisture contents are fundamentally different because Davis (1940) records an average oven-dry content of 123 %, whereas the Jamaican average value is 30.5 %. Text-fig. 8 illustrates the other salient features and it is again clear that total  $\text{Cl}^-$  is considerably greater than the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , though not to the same extent that it was in the peat soils. The sodium is apparently not so closely bound in this type of soil as it is in the peat; there is also a tendency for the total  $\text{Cl}^-$  and  $\text{Na}^+$ , together with the exchangeable base, to behave similarly in relation to increasing depth, though in none of these factors is there any real consistency in behaviour. The carbonate content varies considerably, and with a range of 2.5–12 % is noticeably lower than that of similar soils in Florida where the  $\text{CO}_3$  ranged from 32 to 94 %. It is very evident that with the exception of the *Halimeda* sands the soils of Jamaica are much less calcareous than those of Florida. The humus of the Jamaican soils of this group ranges from 2 to 12 %, whereas in Florida the loss on ignition ranged from 25 to 35 %.

(d) *Siliceous sands*

The analyses of these soils are set out in Table XII, and it will be observed that nearly all the soil passes the 2 mm. sieve, and that the coarse- and fine-sand fractions are very high whereas clay and silt are low. The pH shows no feature of interest. Apart from the moisture contents, which have already been considered, the remaining items are illustrated in text-fig. 9. The Lazaretto soils are in many respects intermediate between this group and the preceding one, as is evidenced by the proportions of the various mechanical fractions and the carbonate content. An interesting feature of the siliceous sands is the fact that the total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$  do not differ greatly, thus suggesting that the  $\text{Na}^+$  ions are readily extracted from this type of soil. The curves for the sesquioxide and silt fractions indicate that there may be some relationship between these two. The percentage of carbonate ranges from 1.5 to 40 %, except in the Lazaretto Pond where it rises to more than 50 %, and these figures compare with 1.44–19 % from the sands of the Florida swamps. The humic content ranges from 0.5 to 4.5 %, whereas in Florida the loss on ignition ranged from 4.18 to 14.09 %.

It is clear from the above analyses that so far as *Avicennia nitida* is concerned there may be a great range in soil type, both as regards physical and chemical structure, and whilst it has been said that mangroves thrive best on finely dispersed muds, nevertheless some extremely fine *Avicennia* plants were seen on some of the cays where the soil was a coarse *Halimeda* sand. Although *Avicennia nitida* occurred in Jamaica over a wide range of soils it was never a pioneer species. In the Old World other species of *Avicennia* may behave as pioneers, especially where the soil is somewhat sandy. There appears therefore to be a fundamental difference in behaviour between the New and Old World species of the genus. There is a considerable range in salinity at all the different depths, and although some authors have believed that each of the mangrove communities possesses a more or less typical average salinity and range, nevertheless it is doubtful whether this is really so except in a very general sense. There is a complication in that one does not know which is the most important soil layer, but on morphological grounds it will presumably be around the 10–20 cm. region. The greatest changes in salinity, however, generally occur in the surface layers, and it is here too that the maximum values are attained. The salinity may fluctuate very considerably, and until soil samples have been collected from one area over a much longer period of time it would not be desirable to draw conclusions from the results that have been obtained. The importance of seasonal changes has already been emphasized (Chapman, 1940) for salt marshes, and it is clear that the character of the tides, the periods of non-tidal exposure, the

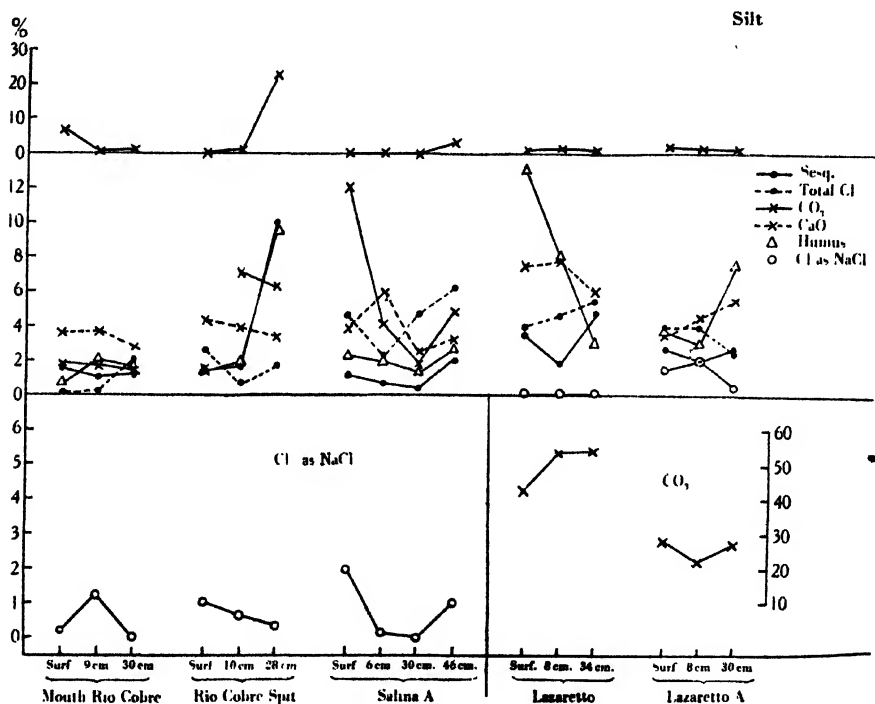
TABLE XI

Site	No.	Soil not passing 3 mm.	Soil not passing 2 mm.	Soil passing 2 mm.	Moisture		pH	CO <sub>2</sub>	Humus	Coarse sand	Fine sand	Clay	Silt	Sequi-oxide	Loss on solution	Cl (total)	Exch. CaO
					Wet wt.	Air dry											
Surface, Up Rio Cobre	17	2.7	1.65	95.65	18.64	3.00	7.7	4.98	5.89	26.45	38.7	5.77	20.55	10.21	+15.55	10.56	3.91
10 cm., Up Rio Cobre	18	0.35	0.71	98.64	23.47	2.91	7.7	4.29	11.65	18.79	35.62	10.47	17.20	3.89	+4.82	4.70	1.94
34 cm., Up Rio Cobre	19	0.9	0.2	98.9	26.53	2.10	7.7	5.43	5.15	18.63	37.96	13.3	16.12	4.18	3.07	3.01	4.95
Surface swamp, near Salina A	26	2.0	0.0	98.0	54.08	2.86	7.7	5.87	8.22	45.87	17.96	7.75	2.82	2.43	6.22	1.94	13.69
Surface, Salina C	31	1.55	0.75	97.7	31.52	8.22	7.7	9.02	11.98	10.01	22.52	18.15	15.80	7.18	+2.26	17.00	4.05
4 cm., Salina C	32	0.7	0.5	98.8	15.62	1.88	7.7	5.65	2.13	19.21	41.98	9.12	18.25	2.02	0.24	7.59	3.92
60 cm., Salina C	33	2.3	1.4	96.3	18.06	3.05	7.7	3.1	4.26	37.1	23.29	14.27	10.8	1.91	2.42	5.6	4.38
Surface edge, Salina C	35	2.1	0.1	97.8	33.12	3.34	7.7	4.74	7.8	14.94	29.43	16.12	18.85	0.7	4.28	1.84	5.88
10 cm. cut swamp, Rio Cobre	38	2.09	0.3	97.61	14.76	2.54	8.0	3.1	4.94	39.93	26.48	5.05	15.65	3.23	+1.1	11.67	2.97
57 cm. cut swamp, Rio Cobre	70	4.6	2.7	92.7	22.23	2.67	8.0	4.48	6.12	34.58	24.67	14.32	18.03	2.82	+8.64	3.25	3.86
Surface, Fort Augusta	37	0.05	0.05	99.9	31.23	2.53	7.7	2.5	7.2	3.49	20.76	13.55	15.06	3.97	1.02	4.06	5.18
13 cm., Fort Augusta	34	0.4	0.2	99.4	20.03	1.5	8.0	10.95	3.69	5.16	59.62	6.7	11.45	2.63	1.91	4.58	4.43
30 cm., Fort Augusta	43	0.0	0.0	100.0	27.76	3.13	7.7	8.83	5.94	3.0	22.33	3.07	33.0	8.85	2.82	45.9	7.3
										4.89	15.74	36.3	26.4	3.29	+1.39	7.86	2.10

TABLE XII

Site	No.	Soil not passing 3 mm.	Soil not passing 2 mm.	Soil passing 2 mm.	Moisture		pH	CO <sub>2</sub>	Humus	Coarse sand	Fine sand	Clay	Silt	Sequi-oxide	Loss on solution	Cl (total)	Exch. CaO
					Wet wt.	Air dry											
Surface, Mouth Rio Cobre	9	3.2	4.6	92.2	8.69	0.35	7.6	1.85	0.74	93.26	1.55	0.806	1.86	1.44	+1.35	0.0	3.67
15 cm., Mouth Rio Cobre	15	3.3	3.1	93.6	12.97	0.43	7.7	1.76	1.95	93.71	0.78	0.32	0.68	1.07	+0.7	0.21	3.62
30 cm., Mouth Rio Cobre	16	5.1	4.1	90.8	19.87	0.57	7.7	1.42	1.62	90.76	3.03	0.22	0.7	1.09	0.39	1.85	3.76
Surface, Salina A	27	0.0	0.0	100.0	14.06	0.53	8.0	12.0	2.34	46.78	30.93	0.72	0.03	1.11	2.56	4.66	3.85
6 cm., Salina A	28	0.0	0.0	100.0	13.87	0.38	8.0	4.13	1.92	68.36	22.26	0.50	0.10	0.72	1.73	2.19	4.9
30 cm., Salina A	29	0.1	0.0	99.9	22.18	0.52	7.7	1.84	1.21	65.67	27.86	0.10	0.20	0.47	2.06	4.74	2.39
46 cm., Salina A	30	0.45	0.2	99.35	24.69	0.89	7.7	4.87	2.76	34.79	47.23	0.0	0.97	2.04	4.45	6.14	3.22
Surface, Rio Cobre Spit	44	0.9	1.6	97.5	5.64	0.5	7.7	1.33	1.39	93.50	0.73	0.0	0.32	1.41	0.82	2.60	4.35
10 cm., Rio Cobre Spit	45	19.8	15.1	65.1	21.8	0.97	7.7	7.09	7.16	77.18	1.6	0.75	0.9	1.63	8.05	0.74	3.87
28 cm., Rio Cobre Spit	46	0.2	0.2	99.6	52.12	3.86	7.7	6.2	9.2	3.57	16.28	32.83	22.72	10.0	+4.76	1.76	3.44
Surface, Pond, Lazaretto	20	0.18	0.0	99.82	19.7	1.32	8.0	47.4	13.25	34.05	5.5	0.6	1.05	1.61	+8.26	4.01	7.51
8 cm., Pond, Lazaretto	21	0.16	0.0	99.84	21.08	1.35	8.0	53.22	8.36	30.54	18.12	1.42	1.13	1.81	+21.63	4.74	7.57
34 cm., Pond, Lazaretto	22	0.3	0.1	99.6	24.91	0.6	7.7	57.15	3.33	28.54	9.41	1.17	1.03	4.79	2.02	5.72	6.94
Surface, Lazaretto A	23	0.7	0.3	99.1	12.71	1.11	7.6	23.9	1.64	50.34	13.31	2.2	2.02	2.73	4.28	4.31	5.75
8 cm., Lazaretto A	24	0.1	0.1	99.8	19.46	1.1	7.7	21.79	3.04	62.85	8.5	0.75	1.85	2.08	+1.96	4.29	4.57
30 cm., Lazaretto A	25	0.05	0.0	99.95	20.04	1.14	7.7	26.81	7.08	66.06	6.58	0.0	1.7	2.66	+14.12	2.87	5.5

incidence of two very rainy months, the general absence of minor creeks, and the very different types of soil are all factors that may lead to very considerable daily or seasonal variations in salinity. Such variations would not, however, affect the disparity between the total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$  ions. The total  $\text{Cl}^-$  concentration in both soil and plants is high, and some extra energy will have to be produced during respiration because absorption takes place against a gradient. Van Eijk (1939) has shown that the extra energy required may not be very much; it has been suggested by Troll & Dragendorff (1931) that the extra oxygen required for the additional respiratory activity may be related to the development of the 'breathing' roots. This would seem to be a problem capable of experimental proof. There is little doubt that the development of aerenchyma in these plants is associated with the oxygen supply, but exactly in what manner we do not yet know.



TEXT-FIG. 9. Chemical analyses of siliceous soils.

## 6. WATER-TABLE AND DRAINAGE

A series of pits and tubes were established on the Fort Augusta spit in the glade east of Salina B.<sup>1</sup> The pits and tubes were in pairs, the first pair being situated at the edge of the glade amidst young bushes, and the others at suitable intervals passing towards the centre of the glade. It was hoped that some information about the movements of the water-table could be obtained in a manner similar to that used on the Norfolk marshes (Chapman, 1939). The electrical recorders employed in that investigation were useless in this case because the peat retained too much water at all times. Readings in tubes were taken by means of bamboo canes, and as the tubes were levelled to expedition datum the heights of the water-table could be referred to the swamp level

<sup>1</sup> See map in previous part (Chapman, 1944).



and the tides. Series of readings were taken on 17, 19 and 21 August, and the results indicated that there was very little movement of the water-table in relation to the tide, the fluctuations being of the order of 2-3 in. Further observations showed that there is no great change in level throughout a single tidal period, but there is some fall during periods of non-tidal exposure. There had been no tide over the swamp between 23 August and 7 September, and in that time the level in tube 1 (at the edge of the glade) dropped 0.68 ft., in tube 2 0.31 ft., in tube 3 0.19 ft., in tube 4 there was a slight rise of 0.17 ft. (this tube behaving in an anomalous manner throughout), and in tube 5 the level dropped 0.34 ft. Even over this period of 16 days the maximum fall in level had only been  $7\frac{1}{2}$  in. and the average  $4\frac{1}{2}$  in., a feature that can be associated with the small tidal range. This drop during the periods of non-tidal exposure is the most significant feature of the water-table, and it means that the horizontal roots and the bases of the pneumatophores, both of which are not far below the soil surface, must be clear of standing water for considerable periods of the year. We must therefore abandon the idea that the roots of all mangroves are perpetually bathed in water. This fact is also of considerable importance when we come to consider the functions of the pneumatophores. Davis (1940) considers that the water-table is probably the most important factor determining the zonation. After allowances have been made for seasonal fluctuations the average levels of the water-table in the Jamaican swamps have been estimated as follows:

	In. above or below soil surface
Pioneer <i>Rhizophora</i>	+ 16
Mature <i>Rhizophora</i>	+ 10
<i>Avicennia</i>	+ 6
<i>Conocarpus</i>	- 4
Scrub mangrove	- 3

Whilst the water-table may be a factor determining zonation it is probably not its average level which is important, but the level to which it descends during the longer periods of non-tidal exposure.

Numerous samples of the surface water and of the soil water-table were collected in different localities; these were then taken to the laboratory at Hope where they were analysed at once for pH by colorimetric methods, for total  $\text{Cl}^-$  by electro-potential, for oxygen by Winkler's method and for carbon dioxide by adding very dilute lime water and back-titrating with standard acid. The sample bottles were always completely filled with the sample and the stoppers were close-fitting so that any gas exchange was reduced to the minimum. The water-table samples were either obtained by digging a pit and collecting the water directly into the bottle as the pit filled, or else by making a long deep narrow hole into the soil and sucking up the water through rubber tubing and transferring it to the sample bottle. In such cases the first sample of water withdrawn was always discarded. In Table XIII the only feature of interest in pH is the high value from the centre pond on Lime Cay, but at present no explanation of this can be offered. The carbon dioxide percentages are notable for the low values and for a complete absence from the waters of the Fresh River in a place where there was a rapid transition to fresh-water vegetation. Attention is also drawn to the low oxygen concentrations: there were three areas with apparently no oxygen in the water. The oxygen concentrations, however, must be subject to fluctuations because Troll & Dragendorff (1931) have shown that in estuarine areas in East Africa the oxygen concentration of a flood tide may be 2.07%, but that at the end of the flood period, when stagnation sets in, it may fall to 0.83%. In any case these mangrove values are low in comparison with a mountain stream where the percentage may rise to 5.16; this fact is of considerable importance when we come to consider the functions of the pneumatophores. It is also of interest to compare the chloride concentrations with those obtained by Davis (1940) from the mangrove swamps of Florida. From Table XIV it will be seen that the chloride

TABLE XIII. *Analyses of surface water*

Site	% Cl <sup>-</sup>	pH	% O <sub>2</sub>	% CO <sub>2</sub>
Centre pond, Lime Cay; <i>Rhizophora</i>	2.15	8.9	—	—
N.E. pond, Lime Cay; <i>Avicennia</i>	2.58	8.3	—	—
Pond, Gun Cay; <i>Laguncularia</i>	2.51	7.9	—	—
Surface water, Salina C; <i>Avicennia</i>	1.05	—	0.58	0.002
Surface water, tram track; <i>Rhizophora</i> + <i>Avicennia</i>	0.05	—	0.04	0.004
Surface water, tram track; <i>Rhizophora</i> + <i>Avicennia</i>	0.19	—	0.0	0.005
Tide on open Salina B	1.27	8.0	0.30	0.005
Tide in <i>Avicennia</i> , Fort Augusta	1.23	7.8	0.27	0.010
Tide in <i>Avicennia</i> , Fort Augusta	1.36	7.5	0.25	0.004
Mouth of Fresh River; <i>Rhizophora</i>	0.04	7.8	0.38	0.0
Up Fresh River; <i>Avicennia</i> + fresh vegetation	0.05	7.2	0.10	0.0
Mouth of Rio Cobre; <i>Rhizophora</i>	0.58	8.0	0.0	—
Spanish Town Road; <i>Avicennia</i>	0.3	7.5	0.01	0.02
Transition to Salina; Spanish Town Road	0.66	7.6	0.01	0.02
Pool without gas, Rio Cobre; <i>Rhizophora</i>	1.54	7.5	0.0	0.002

TABLE XIV

	% Cl <sub>2</sub> in the surface water	
	Florida	Jamaica
Atlantic Ocean	3.7	—
Gulf of Mexico	3.26	—
Pioneer <i>Rhizophora</i>	3.13	—
Mature <i>Rhizophora</i>	3.49	2.15
<i>Avicennia</i>	3.68	1.23, 1.36, 0.58
Brackish mangrove	1.56	0.19, 0.3, 0.66
Fresh-water mangrove	0.01	0.0
Scrub mangrove	4.58	1.05, 1.27
<i>Laguncularia</i>	1.29	2.51

values from Jamaica are, with one exception, much lower than those obtained in Florida, probably because Hunts Bay is relatively unaffected by tidal flow and also because of its configuration would tend to retain the fresh water flowing into it from the Rio Cobre, Fresh and Salt Rivers. In view of the fluctuations which may occur in the salinity of the surface waters, this factor is not likely to be important except in so far as it affects the salinity of the soil or the soil water-table.

In Table XV the analyses of the soil water-table from a number of different localities are set out. The concentrations here are of more significance to *Avicennia* plants because the roots will be utilizing this water as well as the soil solution. It will be observed that the carbon dioxide and oxygen contents are extremely low, especially in the peat soils, but this is only to be expected if peat formation is to go on. The pH of the water from the peat is also considerably lower than that from other soils. There are very marked differences between the peat areas and the other habitats, but, as most of these are correlated with the formation of peat, it must be considered that the plants are ultimately responsible for these differences, and that therefore they are of little or no significance in controlling plant distribution or zonation. Troll & Dragendorff (1931) also reported an entire lack of oxygen from the water-table of the African mangrove swamps, and it is clear that although oxygen is not necessarily wholly absent from mangrove areas, nevertheless it is sufficiently low to emphasize the importance of the aerating function of the pneumatophores.

TABLE XV. *Analyses of soil water-table*

Site of water-table	Cl <sup>-</sup>	pH	O <sub>2</sub>	CO <sub>2</sub>
N.E. pond, Lime Cay; <i>Avicennia</i>	2.35	8.2	—	—
Gun Cay; <i>Laguncularia</i>	2.22	8.1	—	—
34 cm. Lazaretto Salina; <i>Avicennia</i>	4.11	8.0	—	—
30 cm. Lazaretto; large <i>Avicennia</i>	3.8	8.2	—	—
60 cm. Salina north of Dawkins Pond	—	—	0.26	0.009
4 30 cm. Salina A	4.06	—	0.1	0.009
1 Sand-spit, Rio Cobre; <i>Laguncularia</i>	1.35	7.5	0.01	0.003
1 Sand-spit, Rio Cobre; <i>Rhizophora</i>	1.91	8.8	—	—
2 52 cm. up Rio Cobre; <i>Avicennia</i>	1.37	7.2	0.03	—
3 30 cm. up Rio Cobre; <i>Avicennia</i>	3.18	7.6	—	—
Aerodrome, Peat, Palisadoes; <i>Avicennia</i>	1.27	6.6	0.0	—
30 cm. peat, Port Royal; <i>Avicennia</i> + <i>Rhizophora</i>	1.95	6.8	0.0	—
Peat, Galleon Harbour; <i>Avicennia</i>	0.13	6.1	0.13	—
Peat, Careening Cay; <i>Avicennia</i>	—	7.2	0.0	—
Peat, Drunkenman's Cay; <i>Avicennia</i> + <i>Rhizophora</i>	1.07	—	0.0	—

The salinity varies considerably and the author agrees with Davis (1940) that *Avicennia* can tolerate a very wide range, including extremely high concentrations in surface and soil waters. This is in contrast to Penfound & Hathaway (1938), who recorded a range of only 3.68–4.97 % Cl<sup>-</sup> for *Avicennia* in Louisiana, but this may be due to special local conditions. In East Africa, Walter & Steiner (1937) found that the salinity of the soil water-table increased as one proceeded landwards from the seaward edge of the swamp, and that therefore it became increasingly difficult for plants to absorb water. This progressive change was reflected in the zonation of the vegetation because it usually terminated in a bare salina with a very high salinity. There is a little evidence from the Jamaican swamps that there may be a transition of this category. The samples numbered 1–4 can be regarded as representing a series, sample 2 being taken in the swamp not far from the mouth of the Rio Cobre, sample 3 from some way up that river, and sample 4, although it comes from the salina on the Fort Augusta spit, nevertheless is indicative of the values likely to be obtained in places where the mangrove swamp is giving way to salina. Davis (1940) also found much the same conditions in Florida when proceeding from the pioneer, *Rhizophora* to the scrub mangrove on the salt flats (Table XVI). The figures for Jamaica in the table are not absolute averages because

TABLE XVI. *Average percentage Cl in soil water in successive plant communities*

	Pioneer <i>Rhizophora</i>	Mature <i>Rhizophora</i>	<i>Avicennia</i>	Scrub mangrove	Mature mangrove	<i>Cono- carpus</i>
Florida, % Cl	2.91	3.56	5.11	8.42	2.21	1.8
Jamaica, % Cl	—	1.91	2.78	4.08	1.43	—

samples were only collected at one period of the year, but at the same time they provide an indication of the conditions. It would seem, therefore, that salinity might be an important factor in controlling zonation, and it is suggested that it will operate most powerfully towards the end of the periods of non-tidal exposure, and also that it will probably act through control of seedling establishment rather than upon the adult trees. Future work should determine the range of tolerance of seedlings of these species towards salinity and also the values at which their optimum growth takes place. Some indication of the importance of this aspect is revealed by Penfound & Hathaway (1938), who state that *Avicennia* seedlings begin development in the spring when the sodium chloride of the water-table has a concentration of 1% and that of the soil water about 4%.

They report that the seedlings will not start to develop under conditions of higher salinity. These results tend to stress still more the great importance of the periods of non-tidal exposure, not so much in the direct but rather in the indirect effects which they exert.

### 7. AERATION

In view of the importance attached to the pneumatophores of *Avicennia* as organs for gaseous interchange with the atmosphere because of the poor oxygen conditions in the soil, it was very desirable to analyse the soil atmosphere in order to determine the proportions of carbon dioxide and oxygen present. In the mangrove swamps of East Africa Troll & Dragendorff (1931) recorded a complete absence of oxygen from the soil atmosphere except in the uppermost 5 cm., whilst the carbon dioxide ranged from 0.31 to 0.42%. Davis (1940) considers aeration to be important because it decreases with water stagnation; the resulting suffocation in paludal basins then leads to the development of scrub mangrove. This latter point requires further investigation because in the Hunts Bay swamps many stagnant pools with no apparent aeration nevertheless possessed well-grown trees. Scrub vegetation would appear to be more closely correlated with increasing salinity, especially since it frequently abuts on to salina.

Samples of gas were extracted from areas in the swamps either when the flood tide was over the ground or else by utilizing local pools of water. If gas is present when a stick is plunged into the mud and withdrawn gas bubbles follow and these can be collected. To avoid errors due to long stagnation it is desirable to collect when the flood tide is covering a swamp. The gas was collected in an inverted glass funnel filled with a 1:1 mixture of pure glycerine and saturated salt solution, since both carbon dioxide and oxygen are more or less insoluble in this mixture. The collected gas was then transferred in the field to a small gas holder filled with mercury and inverted over a trough of mercury. This transfer was achieved by means of a fine glass syringe pump with the

TABLE XVII

Description of site	% CO <sub>2</sub>	% O <sub>2</sub>
1. Open Salina B (Fort Augusta spit), 5 yd. from fringe	1.91	5.77
2. In fringe A	8.08	5.67
3. In fringe B	9.17	3.65
4. In <i>Avicennia</i> glade A (peat soil)	11.53	8.09
5. In <i>Avicennia</i> glade B (peat soil)	5.31	6.26
6. In <i>Avicennia</i> glade C (peat soil)	6.26	9.61
7. <i>Avicennia</i> , edge of Dawkins Pond	7.89	5.49
8. Live <i>Avicennia</i> among dead bushes, Salina B	4.23	8.84
9. Dead bushes, Salina B	0.74	2.33
10. Dead bushes, Salina B	0.11	2.69
11. <i>Rhizophora</i> fringe, east side of Hunts Bay	4.47	2.45
12. <i>Rhizophora</i> fringe, Dawkins Pond	3.89	11.02
13. <i>Rhizophora</i> fringe, Port Royal	4.97	5.16
14. <i>Rhizophora</i> and <i>Avicennia</i> , up Fresh River with land vegetation	11.53	21.59
15. <i>Rhizophora</i> and <i>Avicennia</i> pool near mouth of Rio Cobre	6.44	5.79
16. <i>Avicennia</i> , Hunts Bay	0.12	0.0
17. <i>Avicennia</i> , Rio Cobre	7.24	6.76
18. <i>Laguncularia</i> , Rio Cobre sand-spit	19.73	8.81
19. <i>Avicennia</i> , Careening Cay	10.74	7.8

end turned up almost at right angles. When the transfer was complete the gas holder was corked and sealed with plasticine. Immediately on arrival at the Hope laboratory the samples were analysed by means of a Bonnier and Mangin apparatus using the method described by Thoday (1913). The results of these analyses are set out in Table XVII. It is at once very obvious that the concentration of oxygen in the soil atmosphere is considerably below that of the external atmosphere, and in one or two

places (Salina B and Hunts Bay) there are values that might well be lethal for the roots in that respiration could not proceed. By way of contrast, the values for carbon dioxide are considerably greater than the concentration of this gas in the external atmosphere. The gaseous atmosphere of the soil has therefore an abnormal composition which might be expected to be deleterious to the plants and to render structures such as the pneumatophores necessary. In the next part, however, it will be shown that all the roots, with the exception of the ultimate absorbing rootlets, are covered with a layer of cork and that therefore they are probably not affected by the soil atmosphere, although some workers have suggested that this cork is pervious to air. On the other hand, the absorbing rootlets are not protected by a cork periderm, and their behaviour will be related to the composition of the atmosphere. The carbon dioxide concentration was low or very low in the salina and approached that of the normal atmosphere; it rose considerably in the *Avicennia* fringe on the edge of Dawkins Pond but tended to fall slightly in the glades. Mature *Rhizophora* bordering the swamps had an average carbon dioxide concentration of 4.4%, whilst in the main *Avicennia* swamps the values rose to between 5 and 12%. Attention must be drawn to the very low concentration of CO<sub>2</sub> in the Hunts Bay swamp and to the very high value from the *Laguncularia* community on the sand-spit protecting the Rio Cobre swamps. These are probably local phenomena and there is no immediate explanation. The oxygen concentration in the Fort Augusta spit tended to be lowest in the salina, then rose at the fringe of the glade and reached its highest values towards the centre. It is worth noting that in the area of dead bushes on Salina B the oxygen concentration was only 2.33 or 2.69%, and this might well be inadequate for the functioning of the roots of young bushes and thus caused their death. The bushes had evidently succumbed before any great number of pneumatophores had been produced. The oxygen conditions were the only apparent factor that might account for their death, but even this is not wholly satisfactory in view of the anatomical features of the root system.<sup>1</sup> The responsible agent is obviously some very local phenomenon, such as oxygen concentration, but it would be worth investigating other areas of dead bushes with a view to ascertaining how far this factor may be operative before coming to any final conclusion.

Although the data are scarcely adequate it is probable that the average oxygen values are lower in the mature *Rhizophora* zone than in the mature *Avicennia* swamp. There are two anomalous values, one from the swamp in Hunts Bay with the low carbon dioxide concentration and the other, a very high value, from the Fresh River region. This latter might have been due to the admixture of air during the transfer process, though if this were the explanation the carbon dioxide concentration should be much lower.

It is clear that the composition of the soil atmosphere may be of considerable importance when we consider the aeration of the roots. It is also evident that if the soil atmosphere communicates with the normal atmosphere by means of the numerous crab burrows, then there must be remarkably little diffusion along these channels. A certain amount of hydrogen sulphide is produced in the mud of the swamps and can be detected by the odour of the gas bubbles as they come to the surface. It has been found that the bacterium *Microspira aestuarii* is associated with the iron sulphate and sulphide in the mangrove muds of East Africa, and it is not unlikely that the same or a similar species is present in the Jamaican muds.

#### 8. SODIUM AND CHLORINE IN ADULT PLANTS

About 200 samples of leaves, stems, roots, pneumatophores and seedlings of *Avicennia* were collected, together with samples of *Rhizophora* and *Laguncularia* seedlings, and analysed for sodium and chlorine in order to determine:

(a) if there was any relation to the concentration of sodium and chlorine in the soil water-table or in the soil solution;

<sup>1</sup> There was also an area of living *Avicennia* in Hunts Bay where the oxygen concentration was nil.

- (b) if there was any gradient in the concentrations of these two ions up the tree;  
 (c) if there was any relation between the concentration of these two ions and distance of the tree from the sea.

As soon as the samples were collected they were first dried in the air and then in an oven: they were then ground up into fragments, placed in small tubes and were again dried in the oven at Hope. After the return to Cambridge the samples were redried at 40°C. and ground up still further in a mincing machine.

#### *Sodium analysis*

A little under 0.1 g. of material was taken and ground up with water in a mortar. The suspension was transferred to a small conical flask and a drop of barium nitrate solution added in order to precipitate any sulphates: in general these were usually absent, but if there was any precipitate it was filtered off. The contents of the flask were brought to the boil in order to ensure the extraction of the soluble  $\text{Na}^+$  and  $\text{Cl}^-$  ions and were then allowed to cool. When completely cold a small quantity of magnesia mixture together with excess of ammonia was added in order to precipitate the phosphates. In the case of the *Laguncularia* and *Rhizophora* samples this precipitate was invariably of a dark brown character which may be due to a higher proportion of tannin present in these plants. The precipitate was filtered off and the resulting solution evaporated to dryness. The residue was extracted with 4 c.c. of water and filtered: 1 c.c. of the filtrate was added to 10 c.c. of zinc uranyl acetate, prepared according to Barber & Kolthoff (1928), and left for two days. At the end of this period the sodium uranyl acetate was filtered off through a Gooch crucible and washed with more uranyl acetate solution, followed by methylated spirits and finally with ether. After allowing to stand 10 min. the crucible was weighed:

$$\log (\text{wt. precipitate} \times 4) + 2.1747 = \log \text{wt. of } \text{Na}^+.$$

#### *Chloride analysis*

About 0.04 g. of material was taken and ground up with water in a mortar and transferred to a conical flask. 2 c.c. of 1:3 nitric acid were added and then 10 c.c. of *N*/100 silver nitrate. The contents were brought to the boil and then 5–6 c.c. of concentrated  $\text{Cl}^-$ -free potassium permanganate were added. Boiling was continued for 10 min., and more permanganate was added whenever the colour disappeared and more distilled water if the contents evaporated too much. As soon as boiling ceased sufficient concentrated  $\text{Cl}^-$ -free dextrose solution was added in order to decolorize the contents of the flask, which were then allowed to cool in the dark. When cold the precipitate of silver chloride was filtered off and the solution titrated with standard sodium thiosulphate with starch as an indicator. A blank experiment was also carried out for each set of determinations, and the difference between the blank and the  $\text{Cl}^-$  analysis gives the amount of  $\text{Cl}^-$  present. The complete analyses are set out in Table XVIII.

The figures in this table show that there is not a great discrepancy between the total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ . It seems evident, however, that there is some differential absorption in favour of the  $\text{Cl}^-$  ions, and this may be correlated with the greater freedom of these ions in the soil (cf. p. 458). It is also obvious that the percentage of chloride present in the plant tissues is higher than that of sea water. It is possible that values have been affected to some extent by the sodium chloride that crystallizes out on the leaves during the middle of the day, but this would only affect samples collected after about 11 a.m., and the majority were collected before that time.

(a) *Relation of total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the sodium in the plant to concentrations in the surrounding soil water-table and soil solution.* The results do not suggest that there is any correlation with the concentrations in the soil water-table, but a greater volume of data would be desirable. Text-fig. 10 illustrates the relationship between the

TABLE XVIII

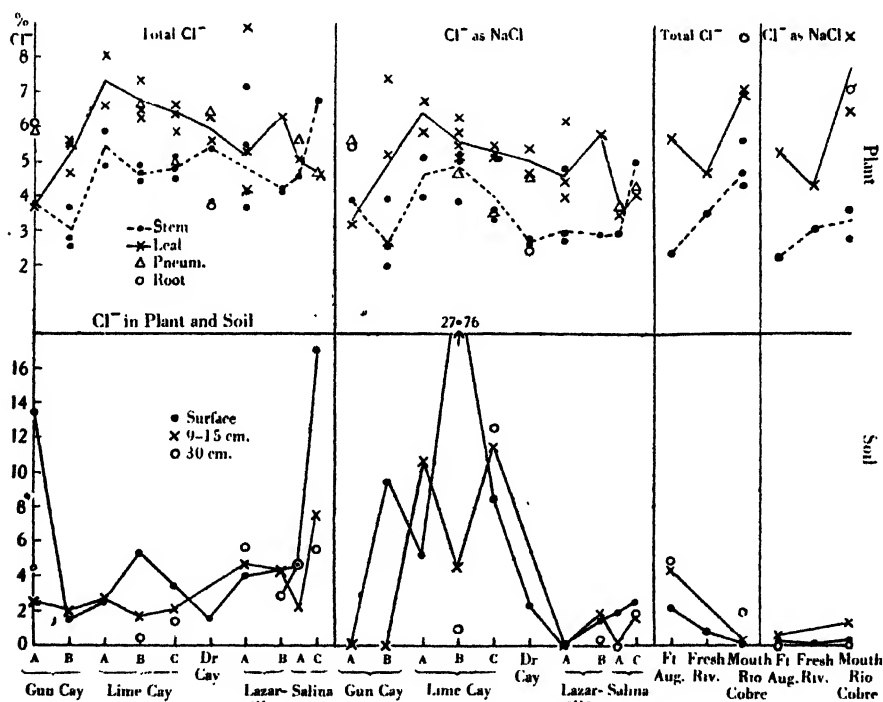
Description	Total Cl-	Cl-as NaCl	Na+	Description	Total Cl-	Cl-as NaCl	Na+
Lime Cay A:				Gun Cay B:			
1 ft., stem	7.26	6.51	4.23	7 ft. stem	2.52	2.57	1.67
1 ft., leaf	7.6	5.39	3.50	7 ft., leaf	5.59	5.15	3.34
4 ft. 6 in., stem	4.4	3.83	2.53	12 ft., stem	3.1	2.08	1.34
4 ft. 6 in., leaf	6.09	3.25	2.11	12 ft., leaf	4.75	3.35	3.35
21 ft., stem	5.84	5.08	3.3	Drunkenman's Cay sand: roots	3.72	2.45	1.59
21 ft., leaf	6.51	5.88	3.82	stem	3.79	2.77	1.80
pn.	6.55	4.68	3.04	leaf	6.27	5.4	3.53
9 in., stem	4.46	5.15	3.35	Drunkenman's Cay rock: 1 ft., root	3.38	2.4	1.56
9 in., leaf	6.48	5.84	3.79	1 ft., stem	4.06	4.0	2.6
1 ft. 6 in., stem	4.87	5.0	3.26	1 ft., leaf	5.99	4.99	3.24
1 ft. 6 in., leaf	6.21	6.25	4.06	2 ft., root	6.85	5.39	3.5
9 ft., stem	4.62	3.87	2.52	2 ft., stem	4.86	4.68	3.02
9 ft., leaf	7.3	5.42	3.52	2 ft., leaf	6.94	6.02	3.91
pn. (sand)	4.93	3.52	2.29	stem	5.38	2.66	1.73
pn. (pool)	6.04	6.1	3.94	leaf	5.59	4.6	2.99
h.root	7.24	6.54	4.25	pn.	6.34	4.58	2.97
1 ft., stem	5.09	5.1	3.31	Avicennia sand	7.34	7.24	4.7
1 ft., leaf	6.56	5.16	3.32	pn. 1 ft., stem	7.1	6.7	4.37
5 ft., stem	4.49	3.54	2.3	1 ft., leaf	7.5	4.99	3.25
5 ft., leaf	6.37	5.44	3.54	1 ft. 8 in., stem	7.15	4.82	3.13
15 ft., stem	4.79	3.34	2.17	1 ft. 8 in., leaf	8.86	6.16	4.0
15 ft., leaf	5.8	5.2	3.3	4 ft., stem	5.45	2.9	1.88
21 ft., stem	4.86	3.94	3.56	4 ft., leaf	4.16	3.97	2.58
21 ft., leaf	8.0	6.72	4.37	10 ft., stem	3.65	2.72	1.76
h.root	6.07	5.46	3.55	10 ft., leaf	5.27	4.42	2.87
3 ft., stem	3.8	3.83	2.5	6 ft., stem	4.2	2.91	1.89
3 ft., leaf	3.7	3.16	2.05	6 ft., leaf	6.23	5.79	3.76
Gun Cay A:				Lazaretto B			

Gun Cay B:	5-82	5-56	3-61	Salina B	5-56	3-69	2-4
pn.	7-61	8-0	5-2		5-26	3-76	2-44
h.root	3-66	3-91	2-56		4-91	4-78	3-1
2 ft., stem	5-61	7-38	4-79		4-59	2-92	1-89
2 ft., leaf	2-75	1-97	1-28		5-04	3-45	2-24
5 ft., stem	4-62	2-63	1-75		4-67	4-2	2-73
5 ft., leaf	5-04	3-84	2-52	Salina C	6-61	4-99	3-24
6 ft., 6 in., stem	6-54	5-07	3-29		4-61	4-0	2-6
6 ft., 6 in., leaf	8-07	6-04	4-32	<i>Avicennia</i> , R.C. mud	5-09	3-0	1-95
<i>Avicennia</i> in pool + gas: root	3-34	2-19	1-43		5-31	6-25	4-06
stem	6-84	5-07	3-29		5-22	3-36	2-18
leaf	2-82	2-28	1-48	Salt River, half-way	2-95	2-25	1-45
<i>Avicennia</i> in pool—gas: 6 ft., stem	7-47	7-29	4-74		4-94	5-37	3-49
6 ft., leaf	3-35	3-89	2-53	Mouth, R.C.	4-31	2-78	1-81
1 ft., stem	6-8	7-18	4-66	Foreshore, R.C.	8-59	7-01	4-55
1 ft., leaf	6-44	3-96	2-57		5-56	3-63	2-36
<i>Avicennia</i> in mud:	4-92	2-95	1-92		4-65	3-59	2-33
pn.	5-58	4-09	2-64		6-91	8-65	5-68
6 ft., stem	5-97	6-79	4-41	Back beach, R.C.	9-54	7-24	4-7
6 ft., leaf	4-29	5-17	3-36		4-41	2-88	1-87
6 ft., stem	4-08	4-46	2-9		7-31	6-2	4-03
9 in., stem	6-34	5-9	3-83		6-25	5-31	3-46
9 in., leaf	6-67	6-2	4-03	Dawkin's Pond	4-21	2-72	1-77
6 in., stem	5-11	3-46	2-25		5-8	4-58	2-97
6 in., leaf	7-06	6-41	4-16	Fresh River	3-51	3-0	1-95
<i>Avicennia</i> in pool + gas: pn.	4-52	4-4	2-86		4-64	4-28	2-77
stem	5-04	4-72	3-04	Fort Augusta	2-34	2-21	2-65
leaf	5-52	5-59	3-63		5-63	5-2	3-89

pn. = pneumatophore; R.C. = Rio Cobre; h.root = horizontal root.



concentration of these ions in the plant samples and the soil from which they were taken, and with the exception of the pneumatophores there is no significant correlation between the plant tissues and the concentrations in the soil solution. This may seem surprising in the case of the roots, but a study of their anatomy shows that they are surrounded by an impermeable coat of cork. The pneumatophores, on the other hand, bear the absorbing rootlets and hence might be expected to show some degree of correlation, but even this is not evident. It is clear therefore that in the soil there must be a differential adsorption of  $\text{Na}^+$  and  $\text{Cl}^-$  ions by the colloidal particles and this leaves more  $\text{Cl}^-$  ions free for solution and hence for the plants. There is also a differential absorption of these two ions by *Avicennia*, but as the differentiation is not the same as that of the soil, since the two ions are absorbed more equally, the proportions in the plants do not bear any



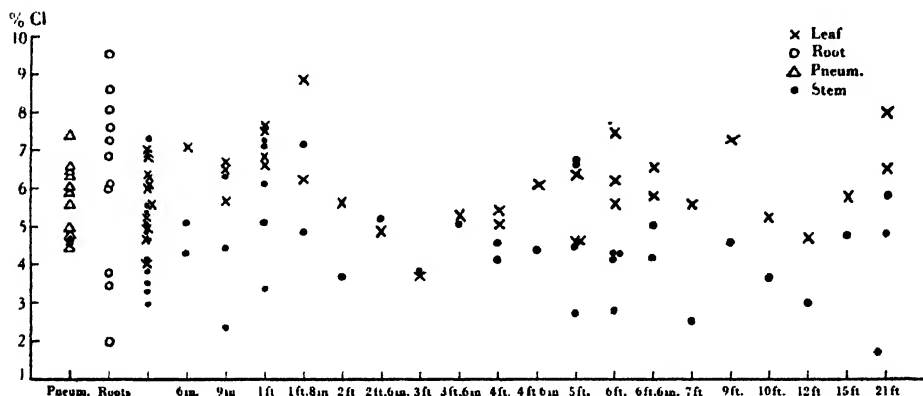
TEXT-FIG. 10. Comparison of total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in plants and soil. The continuous and dotted lines for stem and leaf represent the average values.

resemblance to the proportions of the same ions in the soil. Furthermore, the different types of soil are responsible for differences in the degree of adsorption of the ions. Unfortunately, the plant samples all came from trees growing in *Halimeda* sand, siliceous sand or peat, and there were none from purely mud soils.

It has already been pointed out that differential absorption of ions is of great significance when we consider the metabolism of the plant, more so indeed than the total quantity of the molecular material absorbed. Van Eijk (1939) has shown that in the case of *Salicornia herbacea* the percentage of the  $\text{Cl}^-$  ions not only controls growth to a considerable extent but also the degree of succulence, whereas a lowering of the transpiration rate is due to the specific action of the  $\text{Na}^+$  ions. It will be important in the future to study the behaviour of *Avicennia* plants in relation to the concentration of these two ions if we are to understand fully the response of the species to its environment.

Text-fig. 10 also shows that with very few exceptions (Gun Cay A, Salina C, Fort Augusta) the total  $\text{Cl}^-$  content of the plant is higher than that of the soil solution, but this is not quite so generally true for the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , especially in respect of the Lime Cay samples. Similar results have also been reported for *Avicennia nitida* and *Rhizophora Mangle* (*R. racemosa*) from the west coast of Africa. The figures, however, indicate that in most of the Jamaican sites the  $\text{Cl}^-$  and  $\text{Na}^+$  ions accumulate within the plants against a gradient, and for this to take place extra energy must be produced. Two mechanisms have been suggested as a means of providing this energy: (a) an increase in the general level of respiration, (b) special increase due to anion respiration.<sup>1</sup> This is a problem that has yet to be studied for *Avicennia*.

(b) *Relation of  $\text{Cl}^-$  concentration to height of tree.* In text-fig. 11 are plotted all the values for the different *Avicennia* samples arranged according to their position on the trees, but in spite of the great number of samples involved it does not appear that there is any important variation with increasing height from the ground. This is in contrast to Walter & Steiner (1937), who found that in *A. marina* there was an increase in the osmotic pressure towards the apex and also in the percentage of sodium chloride (which



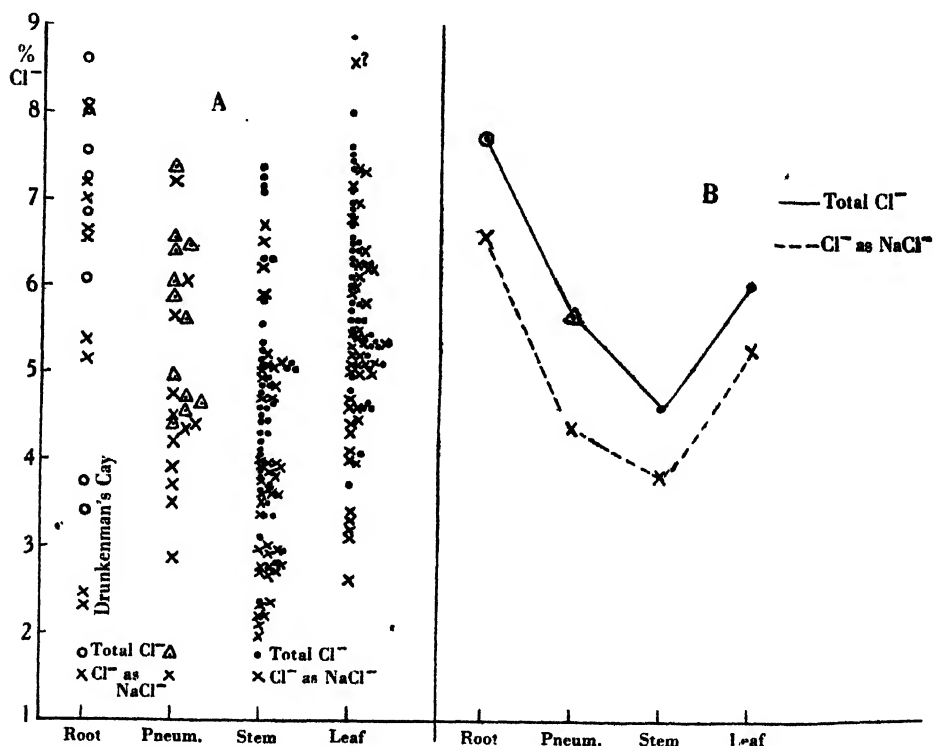
TEXT-FIG. 11. Total chloride and height above ground.

largely determined the osmotic pressure). None of my samples was taken from the very apex of a tree, and as Walter & Steiner's figures only show an increase for the last two pairs of leaves this probably accounts for the failure to repeat the result. The curves in text-fig. 11, however, do suggest that the horizontal roots have higher average values than the pneumatophores and the stems lower average values than either the roots or leaves. There seems also to be some relationship between the fluctuations in the leaves and those in the stem. The difference in values between stems and leaves indicates that there is usually a downward gradient in  $\text{Cl}^-$  concentration in passing from the leaves to the stem at any one point.

In text-fig. 12 the differences between the concentrations of total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$  in the various organs have been analysed further. At *A* the records from all the samples have been set out, whilst at *B* the averages have been computed. In the case of the horizontal roots some very low values from the plants on Drunkenman's Cay have been omitted, and also the sodium value for one leaf has been queried and omitted. With these omissions it will be seen that the highest values are in the horizontal roots, that there is a fall in the pneumatophores and a still further fall in the stems followed by a rise in the leaves to the second highest set of values. Another important point that emerges from the analysis is the relative constancy in the average

<sup>1</sup> For further discussion cf. Chapman (1942).

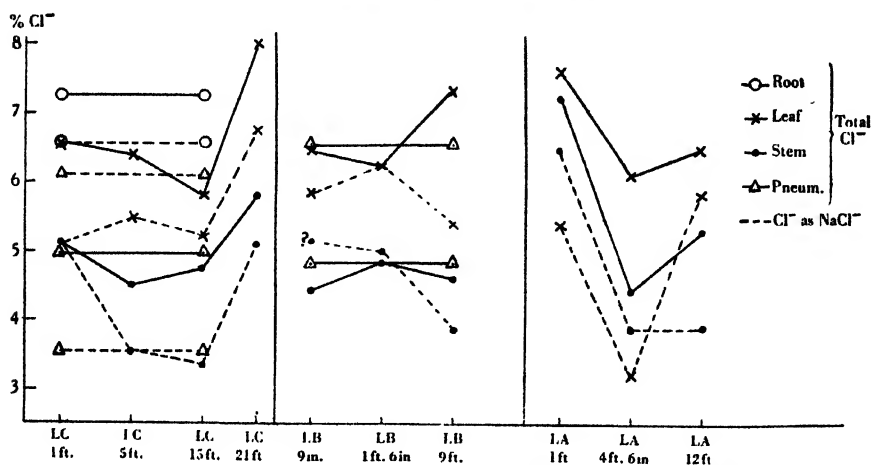
percentage difference between the total  $\text{Cl}^-$  and the  $\text{Cl}^-$  equivalent of the  $\text{Na}^+$ , e.g. 1.2, 1.3, 0.8, 0.8; this may mean that there is a definite relationship between the proportional absorption of  $\text{Cl}^-$  and  $\text{Na}^+$  ions and their distribution throughout the plant. The high values recorded from the roots may be associated with the accumulation of the ions taken in from the soil solution. The transport or diffusion of these ions up the plant will probably be extremely difficult, and hence one may expect the values to be lower in other parts of the plant. It might have been expected that the values in the pneumatophores would be higher still because the absorbing rootlets normally grow out from these organs. The samples, however, were taken from above the point of



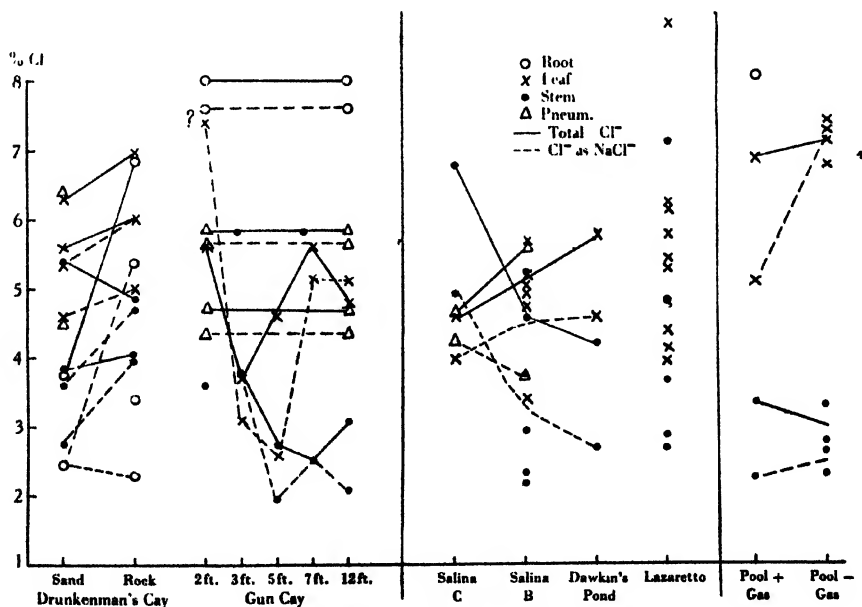
TEXT-FIG. 12. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in different organs. Details on the left; averages on the right.

attachment of the absorbing roots, and it would seem that the absorbed ions travel downwards into the horizontal roots rather than upwards into the aerial portions of the pneumatophores. There may be some lenticular diffusion during the periods of flooding, and this would tend to lower the concentration in the aerial portion of the pneumatophores towards that of sea water. The stem fulfils expectations in that the values are low, but we have still to account for the high values from the leaves. The only reasonable explanation is that rapid transpiration is going on in the day-time, when the samples were collected, and that this results in an increase in the concentration of salt which would be compensated for during the night. Analyses of the leaves over a period of 24 hr. might be expected to show a diurnal fluctuation associated with the degree of water loss.

The figures are employed still further in text-figs. 13 and 14 where samples from individual localities are considered in relation to height. In Lime Cay C the pneumatophore from more or less dry sand had a higher concentration of total  $\text{Cl}^-$  than another



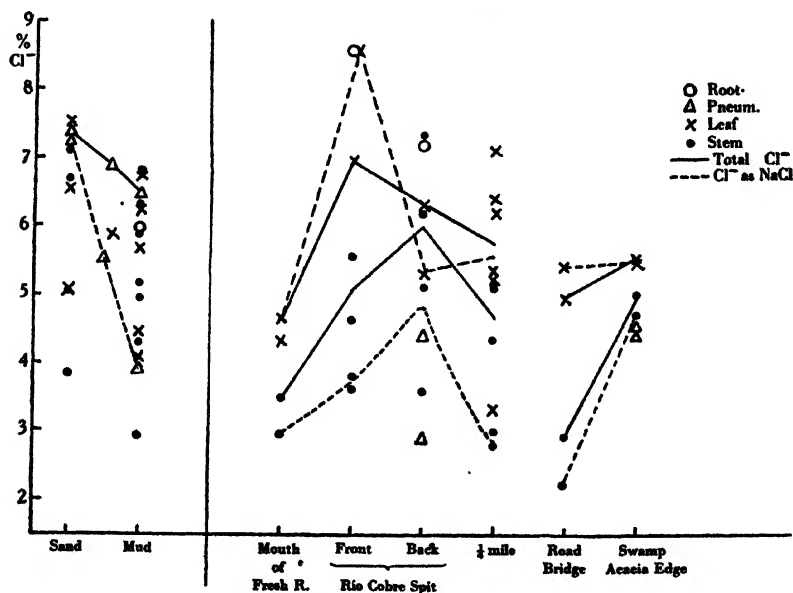
TEXT-FIG. 13. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  showing variations in height for three trees (one given here on the left, one in the middle and one on the right) on Lime Cay.



TEXT-FIG. 14. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in relation to locality.

from a pool of standing water, but this can be explained by diffusion of the water through the lenticels of the pool pneumatophore. In the leaves and stems the chlorid showed a distinct increase in concentration in passing from 15 to 21 ft., and there is therefore some indication of an increasing concentration with height of the tree. I

both Lime Cay A and B there is no such rise, but that may well be due to the fact that the samples were not taken from so near the top of the trees. Lime Cay A was also remarkable for the drop in concentration between 1 ft. and 4 ft. 6 in. In the two plants from Drunkenman's Cay the highest values were recorded from the leaves, whilst a comparison of the two sites showed that the values obtained from the plant growing on the boulders were the greater. There was a tendency for the plant from the rocky rampart to have slightly higher values throughout, and there may be some correlation with the environment. There was a general tendency for the concentrations in the leaves of the two trees on the Lazaretto to be higher than those from Dawkins Pond or Salinas B and C, but this can perhaps be correlated with the higher values recorded from the soil solution. There was no apparent significant variation between the values from the two trees which grew in pools with and without gas respectively.



TEXT-FIG. 15. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in relation to distance from shore.

(c) *Relationship of  $\text{Cl}^-$  content to distance from the sea.* In text-fig. 15 there are the analyses of plants from the mouth of the Fresh River, the foreshore of the Rio Cobre, the back of the sand-spit, some way up the Rio Cobre and, finally, from the Kingston-Spanish Town Road. This series represents successive sites up an estuary, and cannot be expected to give results similar to a coastal swamp of the type described by Walter & Steiner (1937). If the samples from the Fresh River are omitted, as belonging to another estuary, it will be seen that the total  $\text{Cl}^-$  concentration in the leaves falls with increasing distance from the sea until at the far edge of the swamp, where there is a transition to dry scrub, the values rise, perhaps associated with the increasing dryness of the soil: a similar rise is observable for the stems. There is therefore some indication that decreasing salinity up an estuary is reflected in the amount of  $\text{Cl}^-$  and  $\text{Na}^+$  entering the plants.

In their analyses of *Avicennia marina* plants from East Africa, Walter & Steiner pointed out that the chloride concentration in the leaf does not increase with age, and therefore it was argued that the solution passing up the vessels of the plant must contain little or no chloride. If this is so, then presumably the  $\text{Cl}^-$  ions must pass up into the

leaves by diffusion through the cortical cells. There are no data from Jamaica on this point, but the very high concentrations of  $\text{Cl}^-$  in the leaves described above suggest that this conclusion may not be valid: it would seem therefore that this is a problem that requires reinvestigation. *A. nitida* exhibits two features, both of which are usually associated with control of osmotic pressure in halophytes, e.g. succulence and salt-secreting glands, and their presence rather suggests that  $\text{Cl}^-$  is in fact transported up the stem. The extremely high concentrations which are to be found in quite young seedlings (cf. below) can hardly be explained by the phenomenon of diffusion, and a more rapid mechanism would seem to be indicated. Another statement of the above-mentioned workers is that the roots absorb almost pure water and thus act as a filtering mechanism: cut shoots are said to die when placed in salt water because there is no such mechanism. If this is so, it is even more difficult to see how any salt enters the plant in quantity, and yet there is abundant evidence of its presence.

### 9. SODIUM AND CHLORINE IN SEEDLINGS

Walter & Steiner (1937) discovered that when seedlings of *Rhizophora mucronata*, *Ceriops Candolleana* and *Avicennia marina* were analysed the  $\text{Cl}^-$  percentage was much lower than that of sea water, but that as soon as the seedling falls to the ground the  $\text{Cl}^-$  content rises. It does not even then reach the concentration of  $\text{Cl}^-$  in sea water, except in the case of *Avicennia* when the concentration of  $\text{Cl}^-$  ions in the plant attains that of the sea water as soon as the first root has emerged, thus indicating a ready absorption of these ions. This readiness to absorb  $\text{Cl}^-$  ions hardly agrees with the filtering mechanism ascribed above to the roots. The ruptured seed coats of these seedlings were found to have the normal high osmotic pressures associated with the adult plant, so that in passing from seed coat to seed one passed from a region of high to one of low osmotic pressure. The cotyledonary haustoria were suggested as forming the zone in which this change took place. There is also the possibility that the seed condition may be controlled to some extent genetically, and as such represents an ancestral condition. There are other halophytes which exhibit the same phenomenon, e.g. Schratz (1935) has shown that the seeds of *Aster Tripolium* and *Salsola Kali* have little or no traces of sodium chloride.

In view of these very interesting results it was considered desirable to repeat the investigation, and so seedlings of *Rhizophora Mangle*, *Avicennia nitida* and *Laguncularia racemosa* were collected; some were dried immediately for analysis, whilst others were planted and collected subsequently at intervals so that a series of age groups were obtained. Each age group consisted of two seedlings which were divided into cotyledons, roots, stem and leaves for separate analysis, the results of which are set out in Table XIX.

An examination of this table leads to one important conclusion, namely, that the quantity of  $\text{Na}^+$  ions present are more than sufficient to account for the total  $\text{Cl}^-$  present if all the  $\text{Na}^+$  has an equivalent weight of  $\text{Cl}^-$ . This is the very reverse of the state of affairs found in the adult tissues. With the increasing age of the plants it will be noted that the change from one state to another in the stem occurs in *Laguncularia* and *Avicennia* between groups 3 and 4, whilst in the roots of *Laguncularia* the change-over occurs between groups 5 and 6, and in *Avicennia* between groups 1 and 2. In *Laguncularia* there is no definite indication of a permanent change-over in the leaves, but in *Avicennia* there is a change between groups 1 and 2. These results lead to one of the following conclusions:

(1) The differential absorption and diffusion of ions in the young plants is different from that of the older plants, e.g. in the young plant more  $\text{Na}^+$  than  $\text{Cl}^-$  is taken in, but sooner or later the ratio reaches equality and finally becomes reversed. Diffusion as well as absorption would seem to be involved because in *Laguncularia* the change-over occurs in the stem before it does in the root, and although in *Avicennia* the change-over occurs in the roots first the leaves also undergo the change at the same time.

TABLE XIX

Tissue	Total Cl <sup>-</sup>	Cl <sup>-</sup> as NaCl	Na <sup>+</sup>	Tissue	Total Cl <sup>-</sup>	Cl <sup>-</sup> as NaCl	Na <sup>+</sup>
<i>Laguncularia</i>				<i>Avicennia</i>			
1 root	5.93	23.58	15.32	6 root	4.31	2.63	1.75
stem	6.34	7.64	4.97	stem	4.33	4.79	3.11
leaves	9.4	12.02	8.2	leaf	6.31	5.12	3.32
2 root	7.47	12.33	8.01	On tree 1 recep.	3.6	4.15	2.67
stem	4.56	5.02	3.26	emb.	3.06	3.11	2.02
leaves	7.33	4.86	3.16	2 recep.	3.06	0.3	2.79
3 root	11.09	21.13	13.72	emb.	2.13	2.31	1.5
stem	7.26	7.46	4.85	3 recep.	2.06	3.85	2.5
leaves	6.37	9.75	6.33	emb.	2.48	1.59	1.03
4 root	6.02	4.95	4.95	4 recep.	3.65	3.86	2.51
stem	5.81	5.07	3.29	(base) emb.	1.4	4.88	3.17
leaves	7.28	6.23	5.49	(apex) emb.	2.17	2.11	1.37
5 root	5.43	5.97	3.88	Off tree 5 stem	6.06	4.68	3.04
stem	3.81	2.92	1.9	leaf	6.39	4.49	2.92
leaf	6.86	8.0	5.2	6 stem	3.4	3.79	2.49
6 root	5.37	5.25	3.41	leaf	4.2	2.45	1.59
stem	4.7	1.99	1.29	7 stem	4.45	3.79	2.49
leaf	6.25	4.0	2.59	leaf	3.7	1.4	0.91
7 root	5.65	5.21	3.39	in mud, leaf	6.35	7.73	5.02
stem	3.58	2.82	1.83	in mud, stem	7.76	4.33	2.81
leaf	6.5	6.62	4.3	in mud, root	2.97	6.72	4.38
8 stem	4.11	2.98	1.94	primary root	6.79	8.21	5.33
leaf	3.18	6.2	4.05	cotyledon	5.7	3.49	2.27
9 stem	5.0	4.74	3.08	hairs	7.97	10.33	6.71
leaf	5.88	8.08	5.25	testa	1.91	3.83	2.49
seeds R.C.	2.19	2.29	1.49	seed	1.42	5.17	3.36
seeds F.R.	2.28	2.3	1.49	root	1.94	4.13	2.68
1 root	9.67	13.17	8.55	stem	6.07	6.68	4.34
stem	9.45	10.58	7.53	cotyledon	2.91	1.52	0.99
leaf	8.55	30.48	19.79	root hairs	5.14	2.8	1.8
2 root	4.8	1.06	0.68	testa	1.84	1.79	1.16
stem	5.91	4.17	2.68	cotyledon	1.05	0.37	0.24
leaf	7.86	6.91	4.49	total seed	1.55	1.37	0.84
3 root	5.32	2.71	1.78	total seed	7.32	9.1	5.91
stem	3.6	3.95	2.57	testa	0.83	2.19	1.43
leaf	8.96	6.82	4.43	cotyledon	1.48	1.83	1.19
4 root	6.05	4.66	3.03	cotyledon	2.11	1.91	1.24
stem	5.35	4.06	2.61	testa	3.23	3.21	2.09
leaf	6.54	5.39	3.49	root hairs	2.3	2.66	1.73
5 root	7.03	5.17	3.36	root hairs	5.86	4.11	2.65
stem	6.19	3.38	2.19	cotyledon	1.24	2.9	1.88
leaf	7.66	5.24	3.4	in mud, total	1.42	5.17	3.36
<i>Avicennia</i>							

(2) Alternatively it may be suggested that in the young plants much of the  $\text{Na}^+$  is present in combination with kations other than  $\text{Cl}^-$ , but this does not seem very probable.

(3) There is yet another possibility, namely, that in the seedling the  $\text{Na}^+$  ions are freer than they are in the adult, and that with increasing age they become bound up with other substances in such a manner that they cannot be extracted by the usual analytical technique.

At present the evidence is only sufficient to suggest these alternatives.

#### (a) *Rhizophora Mangle seedlings*

The analyses made on a series of different aged plants still attached to the parent tree and of young plants just becoming established are set out in text-fig. 16. It will be noted that the results obtained by Walter & Steiner (1937) are repeated, and that the embryo has a much lower sodium and chlorine content than the receptacle; therefore



TEXT-FIG. 16. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in age series of *Rhizophora* seedlings.

there must be a transition from a parent tissue with a high concentration of these ions to the embryonic tissue with a low concentration. For the young plants off the trees it will be seen that the concentration in the leaf falls with increasing age, and when the plants are self-supporting the  $\text{Na}^+$  is not in sufficient quantity to account for the total  $\text{Cl}^-$ . The stem also shows a tendency to behave in a similar manner.

#### (b) *Laguncularia racemosa* seedlings (text-fig. 17)

The graph shows very clearly that the concentration of  $\text{Cl}^-$  in the seeds is very low, and also that the  $\text{Na}^+$  equivalent is about equal to the total  $\text{Cl}^-$  present. As soon as the seed commences to germinate, however, there is a tremendous rise in the concentration of these ions, particularly the sodium. This persists up to the third age group and it suggests one of two possibilities:

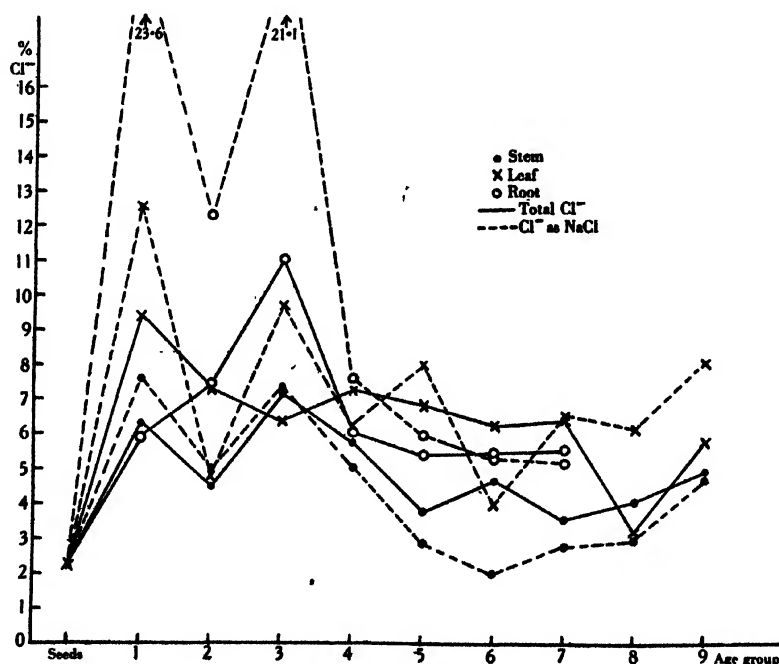
(1) That the principal absorption of the ions takes place in the very youngest stages and the rate then subsequently falls off.

(2) That no means of controlling the absorption of these two ions exists in the young stage, but a mechanism soon develops and then the process is subjected to control. This second alternative could be examined in relation to morphological changes in the roots, e.g. appearance and disappearance of root hairs, appearance of cork, etc., in order to ascertain whether any given feature is associated with this change. The present author would suggest that it is directly associated with the development of cork cambium and periderm.

The meristematic tissues of the young plant must, however, be very resistant in order to tolerate the high osmotic pressures that must be exerted. It is possible that the  $\text{Na}^+$



and  $\text{Cl}^-$  may be present in an osmotically inactive form, as has been suggested, but this hardly seems likely. It will also be observed that up to stage 4 the highest concentrations of  $\text{Cl}^-$  are recorded from the root, the next highest from the leaves and the lowest from the stems. The high concentration in the roots suggests active absorption, whereas translocation may be responsible for the low values in the stem, and transpiration during the day would account for the increase in the leaves. Leaves collected at night should therefore have a lower concentration than comparable leaves collected at midday. With increasing age the concentration in the roots falls below that of the leaves although it remains above that of the stems. This suggests that the change from one condition to the other is perhaps most closely associated with morphological changes taking place in the roots.

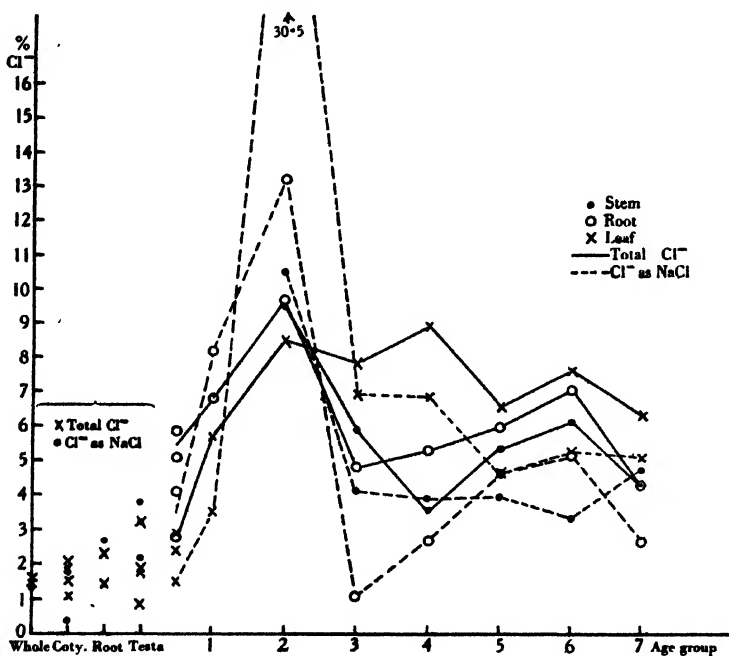


TEXT-FIG. 17. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in age series of *Laguncularia* seedlings.

(c) *Avicennia nitida* seedlings (text-fig. 18)

The graph indicates that this species behaves in a similar manner to *Laguncularia*. The seedlings on the tree possess low concentrations of both  $\text{Na}^+$  and  $\text{Cl}^-$  as compared with that of the leaves and stems of the parent plant. Immediately the seedlings drop off the concentration of both ions increases, and then as the seedlings begin to develop this increase is maintained and there is a sharp rise which is most spectacular for the  $\text{Na}^+$  of the leaf and root. The subsequent drop takes place sooner than it does in *Laguncularia*, which suggests that either *Avicennia* acquires its controlling mechanism much sooner, or else that rapid absorption is limited to a shorter period in the life of the plant. In the very young stages the leaves have a lower  $\text{Na}^+$  and  $\text{Cl}^-$  content than the root, but after the big rise there is a change and the highest concentrations are to be found in the leaves whilst that of the roots falls much lower. The change in the concentrations and the drop from the high to low values are probably associated with

the development of the first adventitious roots and the protective cork layer, a process which will be described in another part. Absorption in the early stages is probably carried out by the felt of hairs on the hypocotyl, especially the basal cells of these hairs, but with increasing age of the roots cork begins to form in the hair region and certain rootlets take on the absorbing function whilst the hairs fall off. There must therefore be some controlling mechanism in the roots which is absent during the time that the hairs are functional. Although there was a big difference in the  $\text{Cl}^-$  concentrations between the receptacle and embryo of *Rhizophora*, there is not such a striking contrast between



TEXT-FIG. 18. Total  $\text{Cl}^-$  and  $\text{Cl}^-$  equivalent of  $\text{Na}^+$  in age series of *Avicennia* seedlings.

the embryo and testa of *Avicennia*. There is some evidence that the concentration of  $\text{Cl}^-$  in the testa is higher than that of the cotyledons and roots, while the difference between testa and roots is less marked than that between testa and cotyledons. It seems clear that there is still plenty of scope for further experimental work in connexion with this extremely interesting phenomenon.

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1939 Cambridge University Expedition to Jamaica.—Part 3. The Morphology of *Avicennia nitida* Jacq. and the function of its pneumatophores. By V. J. CHAPMAN, PH.D., F.L.S.

With Plate 21 and 170 figures in the text.

[Read 28 October 1943]

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## 1. INTRODUCTION

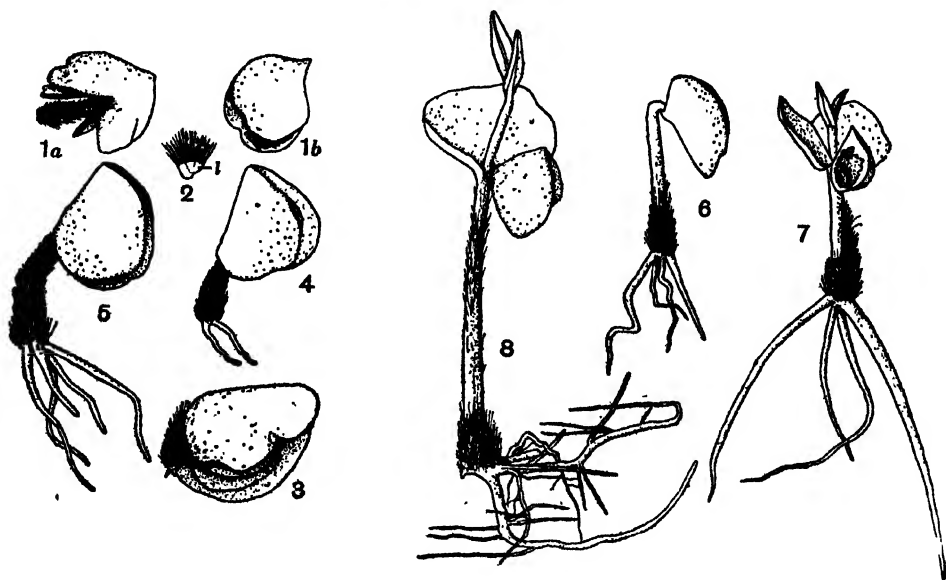
Although the mangroves form an intensely interesting group of plants, nevertheless there is a dearth of really complete and accurate descriptions of their morphology. There are two accounts of the structure of certain organs of *Avicennia tomentosa* from South America, one by Brenner (1902) and the other by Schenck (1889); if, as seems likely, this species is merely a variety of *A. nitida*, the account by the former author is the better of the two. An attempt to give a detailed account of the morphology of *A. nitida* is presented in this paper. The description is based on material collected from plants in different stages of development, while all the drawings with microscopic detail were made from free-hand sections.

## 2. DEVELOPMENT OF THE SEEDLING

The stages in development from the time of fertilization up to the time when the seedling<sup>1</sup> falls from the parent tree were not investigated, but some account of this phase will be found in Treub's paper of 1883. The present investigation takes up the story at the time when the young seedling becomes detached from the parent tree and falls to the ground or into the water. When it has been in the water for a few hours the testa splits open and exposes the young seedling, which at this stage looks very like a broad bean. In text-fig. 1a it will be seen that there are two cotyledons, the larger enclosing the smaller, and that there is also a short hypocotyl of about 1 cm. in length which normally lies protected within the cotyledons. The cotyledons are quite smooth, but the thick hypocotyl is covered with a felt of hairs directed upwards from the base towards the cotyledons. It is possible that a function of these hairs is to prevent the hypocotyl from being dragged out of the soil by the tide once penetration has taken place, or they may render the seedling more liable to stranding as a result of friction with the soil. They also serve as water-absorbing organs during the first few days of free existence. Schimper (1891) has noted that the hypocotyl of this species is longer

<sup>1</sup> In most plants one would refer to the seed, but in *Avicennia* there is no resting period, and growth of the embryo proceeds steadily. Although still surrounded by the testa the young plant is quite capable of an independent existence long before it falls from the parent tree. For this reason I have preferred to call it a seedling rather than a seed. It might also be termed an embryo.

than that of the eastern *A. officinalis* and also that the hairs extend farther up the hypocotyl in *A. nitida*. In text-fig. 2 the extremely short primary root, which is completely devoid of hairs, shows signs of the emergence of the first lateral root, although 24 hr. after liberation of the seedling it is still within the hypocotyl (text-fig. 46). In the 48 hr. seedling (i.e. a seedling 48 hr. after emergence from the testa) the bare radicle has elongated by about  $\frac{1}{4}$  in. Text-fig. 3 is a drawing of a 5-day seedling in which two primary adventitious roots are visible, whilst in the 7-day seedling these two roots have developed to an extent where they can act as anchoring organs; in this seedling the hypocotyl has also begun to elongate (text-fig. 4). Schimper has pointed out that this species produces fewer side roots and also that they develop much more slowly than in *A. officinalis*. It is clear from the account just given that for seven days after the seedling

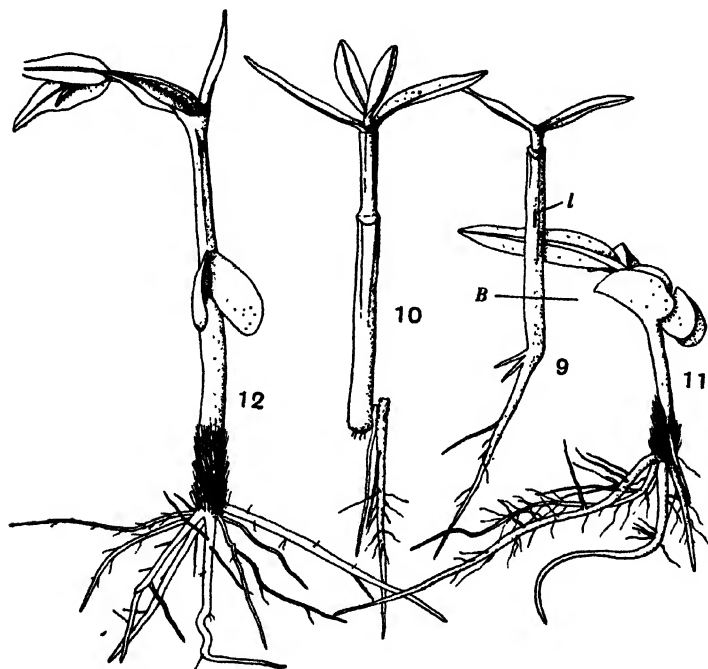


TEXT-FIGS. 1-8. Stages in the external development of seedlings of *Avicennia nitida*. 1 a, b. Seedling after emergence from testa. 2. Base of hypocotyl, short primary root and first lateral adventitious root (l). 3. Five-day seedling. 4. Seven-day seedling. 5. Nine-day seedling. 6. Thirteen-day seedling. 7. Twenty-day seedling. 8. Twenty-six-day seedling.

has been liberated it is in no condition to withstand strong mechanical action by the tides, while a period of non-tidal exposure during these days could be extremely detrimental if not fatal. These facts serve to emphasize the great importance of the seedling stage in a consideration of the factors determining the zonation of the adults.

After the first 6-7 days growth of the roots is rapid, and text-fig. 5 shows a 9-day seedling with five primary adventitious roots; at this stage the plumule also shows signs of growth. Text-fig. 6 represents a 13-day seedling which, though not possessing as many roots as the seedling of text-fig. 5, nevertheless is older because further elongation of the hypocotyl has taken place. A later stage is seen in the 20-day-old seedling of text-fig. 7, in which the plumule is making its appearance above the cotyledons. This seedling also showed signs of animal attack, and indeed many seedlings of about this age have indications of insect, or more probably crab attack on the cotyledons; this, however, cannot be serious because the cotyledons have almost fulfilled their function. At this stage there is also evidence of two types of root development; one in which the roots are stout and relatively unbranched, and the other in which the roots are thinner,

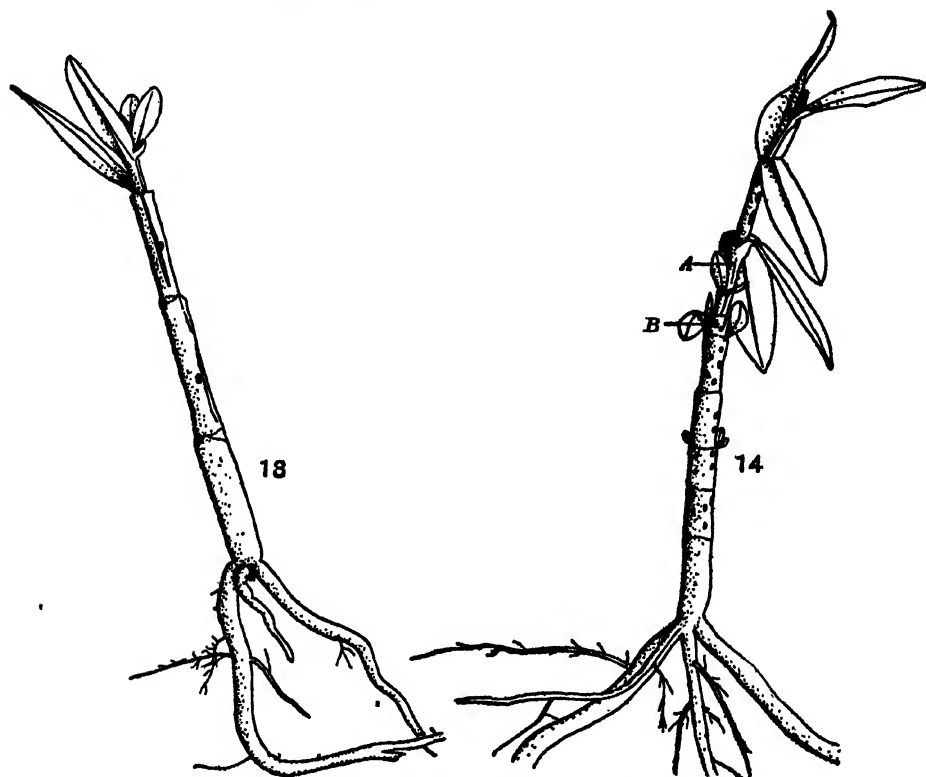
more fibrous and the branching more profuse. Field observations suggest that the type of root is associated with soil type, the stout unbranched root being found in mobile sand areas whilst the fibrous type is associated with mud and peat soils. In text-fig. 8 we have a 26-day seedling; the hypocotyl has increased considerably in length, and the thinning out of the hairs suggests that the principal growing region is just above the base. A longitudinal section confirmed this as the meristematic area and also showed that much of the apparent growth is due to cell elongation. At the apex the plumule had grown considerably and the first pair of leaves were developing at right angles to the cotyledons (the phyllotaxy is opposite and decussate), whilst the primary adventitious roots had developed further and now bore the first absorbing rootlets.



TEXT-FIGS. 9-12. Further stages in seedling development. 9. 'Woody' seedling with first lenticel (*l*). 10. 'Woody' seedling with two pairs of leaves. 11. 'Fleshy' seedling comparable to that of text-fig. 9. 12. 'Fleshy' seedling comparable to that of text-fig. 10.

From this stage onwards there would appear to be two types of development. On the one hand there are those plants which develop relatively slowly, lose the fleshy cotyledons, become 'woody' (in this case through the development of cork) and also have a poorly developed fibrous root system. Examples of this type are seen in text-figs. 9 and 10, and it will be noticed that both have lost their cotyledons, whilst in text-fig. 9 the first lenticel (*l*) is seen and cork has developed from the base up to the level *B*, but it does not extend around the whole of the stem at that position. The roots, though small, have a perfectly characteristic structure with well-developed air spaces, but the number of cells in all the tissues is diminished. In text-fig. 10 may be seen the characteristic ridges that pass down the stem from the leaf and which may be regarded as decurrent leaf bases. The other type of seedling develops more rapidly, retains the cotyledons until a much later stage, does not become 'woody' and has a well-developed

root system. Such seedlings are seen in text-figs. 11 and 12; they are of comparable age respectively with those of text-figs. 9 and 10. Text-fig. 13 is a much older seedling of the 'fleshy' type where the hairs have completely disappeared from the hypocotyl; in the 'woody' seedlings this loss of hairs takes place at an earlier stage. Recognition of these two types is perhaps implied by Davis (1940), when he states that growth is normally rapid but that in the first year anything from four to fourteen leaves may be produced and 3–10 in. of top growth.



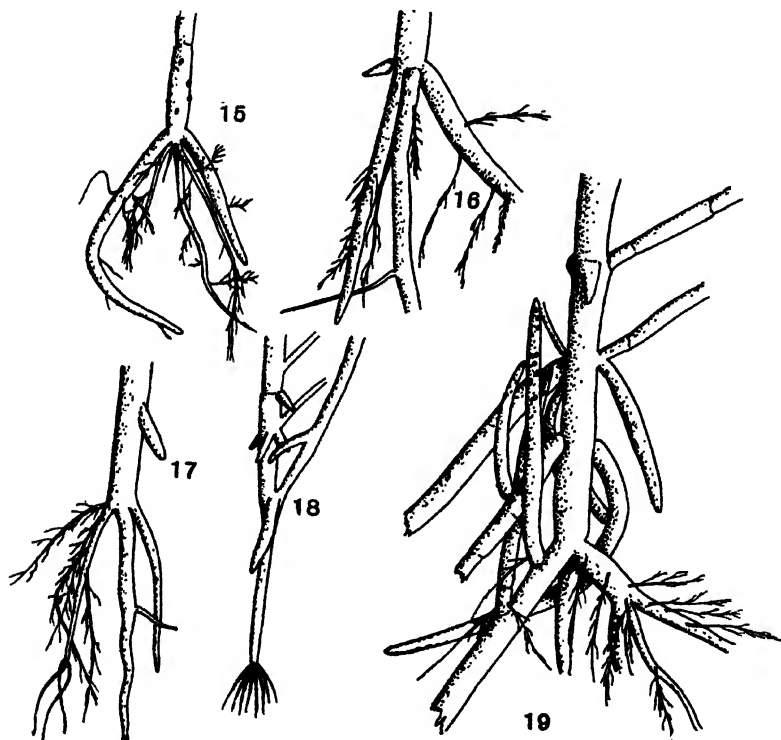
TEXT-FIGS. 13, 14. External development; later stages.

Text-fig. 14 shows a relatively old seedling. Cork is developing in the stem below the third internode from the apex (*A*), and secondary growth is taking place beneath the fifth internode (*B*). The primary adventitious roots are of the fibrous type, whilst the later roots, which have emerged rather higher up the hypocotyl, are of the fleshy type (a feature which is by no means uncommon). Another point to be noted is the growth of the lateral buds in the axils of the lower leaves: these lower leaves fall off fairly early in life and branching is initiated low down on the stem and the trees tend to be very bushy. The distinction between the fibrous and fleshy roots is seen extremely well in text-fig. 15. Further external development is now primarily concerned with the rooting system. There is first a succession of down-growing fleshy adventitious laterals, the primary stage being seen in text-fig. 16 and later successive stages in text-figs. 17 and 18. Although these roots may grow downwards at first they soon lose their positive geotropic response and grow out horizontally about 10–30 cm. below the soil surface.<sup>1</sup> These

<sup>1</sup> This change in geotropic behaviour is worth further study.

down-growing laterals occur at increasingly higher levels, ultimately even above the first branches, and this must be partially associated with the increase in level of the ground surface due to silt or sand deposition. It is from these upper laterals that the negatively geotropic aerial roots or pneumatophores arise, a process illustrated in text-fig. 19, where it will also be observed that some of the down-growing lateral roots have developed from nodes with branches.

In the adult plant the trunk will have grown in thickness by the action of successive secondary meristems, branching will be profuse and the plant generally will have the diagnostic characters by which it is recognized. The rooting system, however, is of

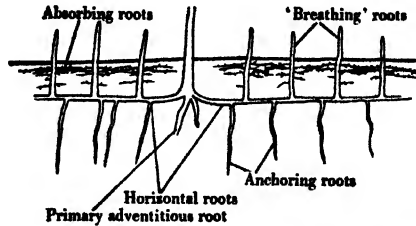


TEXT-FIGS. 15-19. Development of the root system. 15. Fibrous and 'fleshy' roots. 16. Down-growing lateral (horizontal root), 1st stage. 17. 2nd stage. 18. 3rd stage. 19. Stage with origin of pneumatophores from horizontal root. All  $\times \frac{1}{2}$ .

considerable interest. The pneumatophores, which arise from the horizontal roots that are usually about 10-30 cm. below the soil surface, ascend vertically upwards and bear lenticels in those portions that are above the soil surface. The primary adventitious roots more or less degenerate, and the surviving rooting system is therefore shallow but very widespread. A bush 1 ft. in height may have lateral roots extending outwards for a distance of 6 ft. from the stem, and radiating rows of pneumatophores mark the position of the underground horizontal roots. The anchoring roots, which arise near the bases of the pneumatophores, pass downwards from the horizontal roots into the soil. Spreading out from the pneumatophores at a depth of about 2-3 cm. below the soil surface there is usually a network of horizontal rootlets whose function is that of absorption. We have thus five types of root: (a) primary adventitious roots, (b) pneumatophores, (c) horizontal roots, sometimes known as cable roots, (d) anchoring roots,



(e) absorbing roots (cf. text-fig. 20). Of these (a) and (d) are positively geotropic, (b) are negatively geotropic, whilst (c) and (e) are plagiotropic. Schimper (1891) illustrates the pneumatophores of *A. officinalis*, but he does not show any absorbing roots arising from them, whilst Schenck (1889) describes 'earth' roots which arise from the lower part of the pneumatophores of *A. tomentosa*, but it is not clear from his description

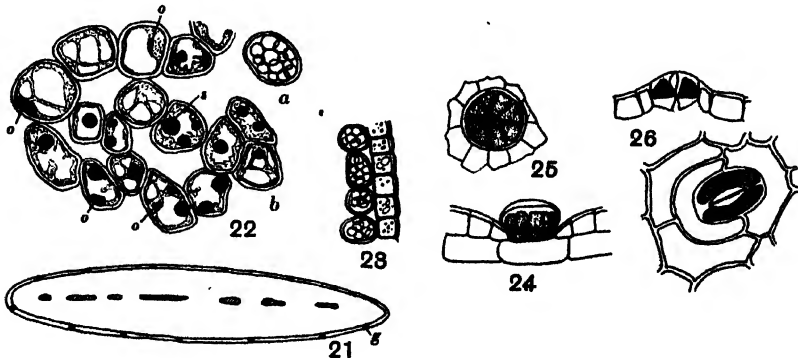


TEXT-FIG. 20. Types of root in *Avicennia nitida*.

whether he is referring to the absorbing roots or to the anchoring roots. Börgesen (1909) has described how, on the main trunk of an old tree, one may find aerial roots which grow out and downwards, sometimes branching and behaving very like the strut roots of *Rhizophora*. These aerial roots, however, are very short and never reach the soil surface; it is reported that their anatomy is similar to that of the pneumatophores. No such aerial roots were seen in Jamaica, so their structure could not be confirmed.

### 3. COTYLEDONS

The cotyledons are extremely fleshy and in transverse section (text-fig. 21) there is a row of vascular strands, which have originated from three primary strands, occupying the centre. Apart from the outer epidermis, the remainder of the cotyledon is occupied



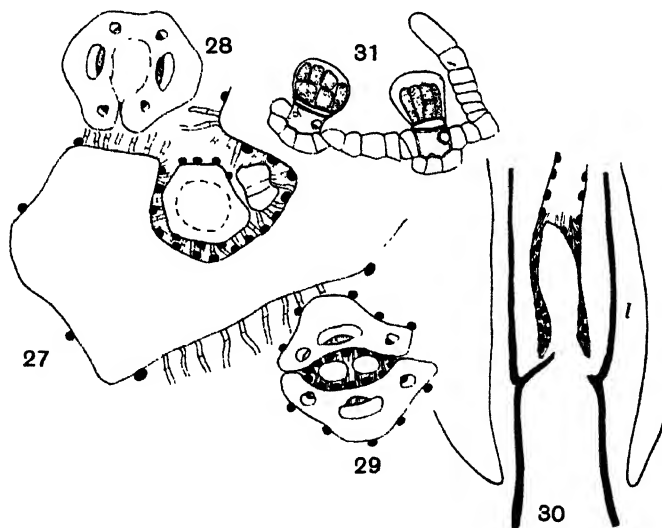
TEXT-FIGS. 21-26. The cotyledons. 21. Transverse section, large cotyledons: *g*=glands. 22a. Mesophyll cell of larger cotyledon filled with starch. 22b. Mesophyll cells of smaller cotyledons: *o*=oil, *s*=starch. 23. Epidermis and hypodermis of cotyledon. 24. Gland in epidermis of cotyledon in transverse section. 25. Surface view of cotyledonary gland. 26. Stomata from cotyledon in surface and transverse section.

by a mesophyll in which are numerous air spaces (text-fig. 22b). The cell walls are mucilaginous, whilst the cells themselves contain starch, fat and protein as food reserves (text-fig. 22a). The bulk of the food reserve is starch, but there are considerable quantities of both fat and protein present. The food reserves do not usually occur in the epidermis although one may find an occasional starch grain. The epidermal cells, which

are square or rectangular in shape, have the outer wall thickened and possess a distinct cuticle. Small air spaces can be distinguished between the more rounded cells of the subepidermal layer (text-fig. 23). Scattered in shallow pits in the epidermis are salt-secreting<sup>1</sup> glands: these structures consist of a compressed stalk cell bearing a multicellular gland which is circular in surface view. Walter & Steiner (1937) report that the cuticle of similar glands on *A. officinalis* appears under the oil-immersion lens to be finely punctured and that the punctures may represent pores, but I have been unable to find any such pores in the glands of *A. nilida* (text-figs. 24, 25). Stomata, which are normal in type, are very rare in the cotyledons and are confined to the lower surface (text-fig. 26). In surface view (text-fig. 26) the presence of lateral walls at right angles to the guard cells indicates that they are of the type in which movement must be obliquely vertical. In the 26-day-old seedling (text-fig. 8) the cotyledons were more or less depleted of starch and some tannin-like material had been deposited in the epidermal cells, though in the cotyledons of the oldest seedling examined (text-fig. 12) starch was still present in some quantity, so that a considerable time must elapse before the store is wholly depleted.

#### 4. LEAVES AND LEAF TRACES

The base of the two cotyledons is shown in text-fig. 27, and it will be noted that there is a dense conglomeration of glands and hairs in their axils. Text-fig. 28 illustrates a



TEXT-FIGS. 27-31. The leaves. 27. Transverse section, base of plumule and surrounding cotyledon. Black dots=glands. 28. Transverse section, first pair of leaves near base. Same plant as text-fig. 28 but higher up. 29. Transverse section, first pair of leaves about mid-way. Same plant as in text-figs. 28 and 29. 30. Diagram of longitudinal section apex showing first pair of leaves (l), vascular strands and glands in black. 31. Glands in plumular pit and a single hair.

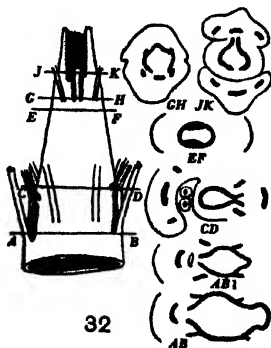
section cut somewhat higher where the separation of the first two leaves is taking place, and it shows the three traces that enter each leaf stalk. Text-fig. 29 is a section cut still higher up, and here the bases of the first pair of leaves are characteristically smothered on the inner side with glands and hairs. After the leaf has unfolded both glands and hairs persist in a triangular area at the base of the lamina (text-fig. 36). The glands have

<sup>1</sup> It is probable that these glands secrete salt, but definite proof is lacking (cf. p. 428).

a shape somewhat different from those of the cotyledon and leaf lamina; the stalk cell is not so compressed, the head is more elongated, commonly consisting of two tiers of cells, and is somewhat pear-shaped, whilst the glands of the lamina, which are not so numerous, are flattened spheres. Wille (1882) has described these glands and Areschoug (1902) has drawn them, but his representation of the basal cell is not entirely satisfactory. The cells in the head of the glands are mucilaginous and stain strongly with ruthenium red. At the point of origin of the first pair of leaves (text-fig. 31) one may also find a type of hair which does not occur elsewhere. It consists of a single row of cells with one large cell at the distal end, and although it is possible that it represents an undeveloped hair of the type found on the hypocotyl (text-fig. 78), it is also possible that it may be yet another type of gland. The presence, however, of unthickened hairs on the outer edge of the glandular area (text-fig. 37) rather supports the view that this kind of growth represents an undeveloped hair of the hypocotyl type, since if cell extension took place it would produce such a structure. Text-fig. 30 depicts a longitudinal section of the plumular region of a 1-day seedling. Sections were also cut in other seedlings in order to establish the number of leaf traces leaving the stem. Boodle & Fritsch (1905) describe three for each leaf but give no further details. In Text-fig. 32 is seen a solid diagram of the vascular supply in the apical region of a seedling, and with it are diagrams of the vascular tissues seen in transverse section at the different levels. It was found that the strands for the cotyledons and leaves do not emerge exactly opposite to each other but that one set departs from the vascular system of the stem slightly before the other. The middle cotyledonary strand usually breaks away before the two lateral strands and immediately above there arises from each side of the leaf gap a strand to the axillary bud, which therefore has only two strands, as compared with three to the cotyledons. After all the strands have arisen from a node the vascular ring, as seen in transverse section, reforms and thickens slightly between the places where the major cotyledonary strands arose. From these thickened areas the central strands of the first pair of leaves arise, the two laterals for each leaf arising more or less at the same level. Again, before the leaf gap closes up, two strands pass from its sides into the axillary bud.

The petioles of the young leaves have small air spaces in the cortical tissues and the central bundle is composed of four or five individual bundles. This marks the beginning of branching in the central strand of the leaf, whilst the lateral strands may also have divided (text-fig. 38).

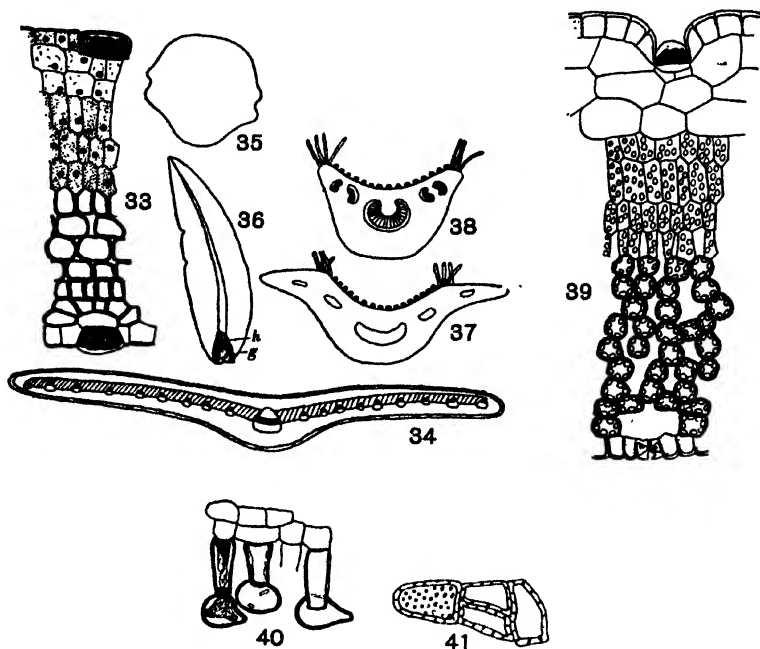
Text-fig. 34 represents a diagrammatic transverse section of one of the first pair of leaves of a 26-day seedling (text-fig. 8) and text-fig. 33 is a drawing of part of this section. It can be seen that already the distinction between the primary tissues has taken place although much further differentiation has yet to occur. Glands are to be found in both the upper and lower epidermis, but so far there is no development of any trichomes (text-fig. 40). At this stage too, many more stomata have yet to develop. Beneath the upper epidermis are two layers of polygonal cells with relatively few granular contents and no plastids: these cells will later enlarge and form the water-storage<sup>1</sup> tissue. Below the water-storage tissue is the palisade tissue consisting of three



TEXT-FIG. 32. Leaf and cotyledonary traces. Diagram of emerging leaf traces and of sections at successive levels in the plumular region. The lowest strands are cotyledonary.

<sup>1</sup> It is believed that the cells of this tissue provide a reserve supply of water which is utilized during the heat of the day. This is an assumption, and it should be subjected to an experimental investigation. It may well be that the use of the term 'water storage' here is incorrect, as it is now known to be in other examples, but for the present this terminology will be retained.

layers of cells still all closely packed. The spongy parenchyma occupies the lower half of the leaf, and even in this early condition the cells are rounding off and forming air spaces. From the base of the leaves, and extending down the stem for some little way, the decurrent petiole persists in the form of ridges (text-figs. 12, 35). Text-fig. 36 represents one of the primary leaves from the seedling of text-fig. 12 and shows the basal triangular area with the glands and margin of hairs. Text-fig. 37 depicts a transverse section through the glandular basal region of the leaf showing the relation of glands and hairs on the leaf, whilst text-fig. 38 shows a transverse section cut near the base of the petiole of a mature leaf. In this mature petiole there is a zone of thick-walled cells



TEXT-FIGS. 33-41. The leaves. 33. Transverse section, immature leaf. 34. Diagram, transverse section of immature leaf. 35. Transverse section, outline of stem below first leaves. 36. Leaf with glandular region (*g*) at base surrounded by hairs (*h*). 37. Transverse section, petiole of young leaf through glandular region. 38. Transverse section, petiole of old leaf through glandular region. 39. Transverse section, mature leaf. 40. Trichomes from under surface of mature leaf. 41. Storage tracheids from centre of mature leaf.

extending from the two flanges towards the centre, and the two lateral bundles have begun to divide although the central bundle does not do so until it is further from the stem. Boodle & Fritsch (1905) report that the three vascular bundles entering the leaf become closed in an annular manner in the petiole to form a single median structure, but there was no trace of this in the petioles I examined, the three leaf traces always remaining quite separate.

Text-fig. 39 is a drawing of part of a transverse section of what is virtually a mature leaf. The glands on the upper surface are sunk in depressions brought about as a result of divisions in the neighbouring epidermal cells together with expansion of the water-storage cells beneath, though not of those immediately below the gland. The water-storage tissue consists of three layers of cells in *A. nitida*, whereas in *A. officinalis* Walter & Steiner (1937) record that it is six to seven cells thick. The palisade tissue in our

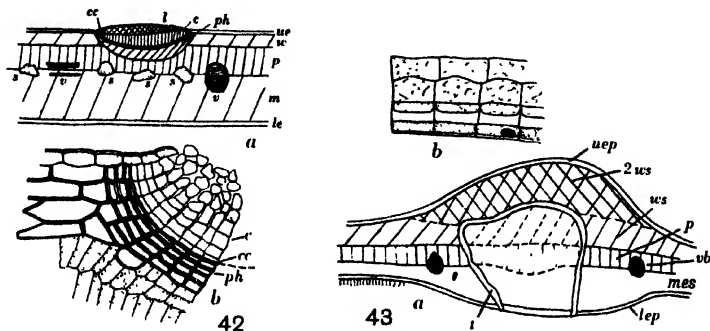
species consists of three to four layers, but the lowermost is transitional in character to the spongy parenchyma. In the two upper layers the cells are closely united, but in the third layer they are somewhat looser and in the fourth layer there are well-marked air spaces. The leaves of *A. officinalis* are also reported to possess three layers of true palisade tissue. The upper part of each vascular strand extends into the palisade tissue (text-fig. 34), whilst the lower portion is embedded in the spongy mesophyll. In the palisade tissue the plastids are scattered densely throughout the cells, whereas in the cells of the spongy mesophyll they tend to be confined to the periphery. In the mature leaf the spongy mesophyll contains numerous large air spaces, whereas in the leaves of *A. officinalis* the air spaces are less numerous and smaller. Typical stomata are to be found in the lower epidermis.

In the fully adult leaf, certain additional features are to be seen. Unfortunately, it was not possible to determine the age of the leaves at which these new features arise because leaves at the requisite age were not collected. One characteristic new feature is the presence of small trichomes (text-fig. 40), which have been described by Areschoug (1902) and also by Boodle & Fritsch (1905), although the drawings in the latter's volume show a stalk cell that is far too short in relation to the head. The literature implies that these hairs may be found over the whole of the lower surface, but this is not strictly correct; one may find areas from which they are completely absent. They must be formed by divisions of the epidermal cells, but no leaves with any developmental stages were obtained. Somewhat similar hairs may replace the glands on the upper surface but they are by no means so common as Areschoug's description suggests. They differ slightly from those of the lower surface in having a shorter stalk, but the characteristic awl-shaped head is present. Similar hairs are to be found on the lower epidermis of leaves of *A. officinalis*. The adult leaf of *A. nitida* also possesses patches of tracheids occupying a zone between the palisade tissue and the spongy mesophyll (text-fig. 41), but again no developmental stages were obtained; it would seem that the tracheids must develop from cells of the intermediate fourth palisade layer and the first layer of the spongy mesophyll. During their development considerable thickening of the walls takes place with the deposition of lignin. Börgesen (1909) refers to these tracheids and Walter & Steiner (1937) record similar ones from the leaves of *A. officinalis*; in this other species they are regarded as having a storage function, a view that is probably correct, as the walls are studded with pits which would allow the passage of materials in solution. The absence of granular contents, however, suggests that these elements may be internal water-storage tracheids. There is, therefore, in these leaves a number of xeromorphic features, e.g. hypodermal water-storage (?) tissue, water-storage (?) tracheids, numerous hairs on the lower surface and a fairly well-developed cuticle. The glands, on the other hand, must be regarded as a halophytic character, their probable function being the control of osmotic pressure in the leaf by removal of excess sodium chloride.<sup>1</sup> The presence of marked xeromorphic characters of course does not necessarily mean that *Avicennia* should be classed as a xerophyte.

Another very peculiar feature of the leaves is the presence of 'lenticel hydathodes' (text-fig. 42), which have been described previously by Areschoug (1902): there is no record of such structures in the leaves of *A. officinalis*. These hydathodes are very sporadic in their occurrence, some leaves possessing at the most only two or three whereas in others they may be quite numerous. Even when they are abundant they are not necessarily spread over the whole leaf but are often localized in patches. On holding the leaf up to the light they are readily visible to the naked eye as brown dots. There is evident opportunity here for an experimental investigation into the factors determining the distribution and development of these peculiar structures. These lenticel hydathodes (if that indeed is their nature, although this is by no means conclusive)

<sup>1</sup> The glands, tracheids and hypodermis should be subjected to an experimental investigation in order to determine their function.

arise in the upper part of the leaf in the water-storage tissue; here a layer of phellogen forms a concave pit and gives rise to rows of cells which round off in the normal lenticel manner. No suberized cells appear to develop outside the phellogen, but the regularly arranged cells of the phelloderm, immediately beneath, have much-thickened mucilaginous walls (text-fig. 42*b*). The palisade cells surrounding the lenticel are affected in that they become inclined towards it. This feature may have some functional significance or it may be due simply to the distortion of the tissues.



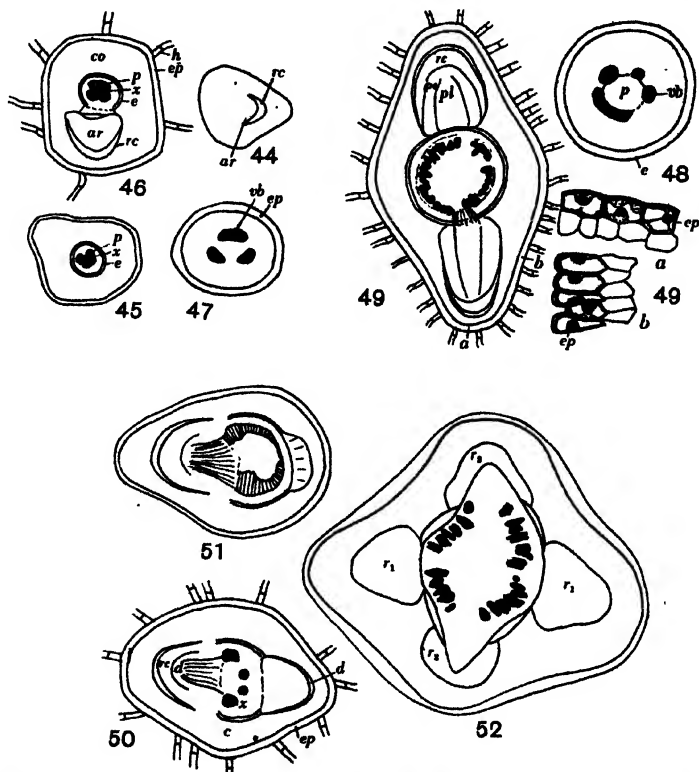
TEXT-FIGS. 42, 43. The leaves. 42*a*, transverse section. Lenticel hydathode (diagrammatic); *b*, drawing of portion. *c*=non-suberized cells, *cc*=cork cambium, *l*=lenticel cells, *ph*=phellogen, *m*=mesophyll, *p*=palisade layer, *le*=lower epidermis, *ue*=upper epidermis, *s*=tracheids, *v*=vascular bundles, *w*=water storage tissue. 43. *a*, transverse section, gall. *lep*=lower epidermis, *mes*=mesophyll, *p*=palisade tissue, *t*=tracheids, *uep*=upper epidermis, *vb*=vascular bundle, *ws*=water storage tissue, *2ws*=new water storage tissue. *b*, drawing of few cells at mouth of gall.

Some leaves were found to be attacked by insects and as a result a gall had developed. This appeared as a small round pustule on both sides of the leaf with the opening commonly on the lower surface. Sometimes a number of pustules fuse, and if the leaf is badly attacked considerable curling and twisting takes place. A transverse section through such a leaf is shown in text-fig. 43*a*, and it will be noted that the water-storage tissue is affected in that secondary meristematic activity has taken place, the active cells being those just outside the gall, whereas a lesser degree of distortion has occurred in the spongy mesophyll. The secondary water-storage cells are perfectly normal in size and shape. The gall itself is surrounded by two or three layers of tracheids which cut off the contained tissues from the rest of the leaf. Although the different tissues could be recognized within the gall, nevertheless modifications had taken place; plastids had disappeared from the palisade cells, the xylem of the vascular bundles was delignified and all the cells contained much mucilage. Another effect is the shedding of the hairs in the immediate neighbourhood of the gall on the lower surface of the leaf although their remains can be seen. At the mouth of the gall the outer walls of the hypodermal layer develop a thick, intense-staining mucilage sheath: there is also some evidence of secondary meristematic activity in this hypodermal layer, but cell divisions appear to be confined to the inner side of the layer (text-fig. 43*b*). The many attempts to determine the originators of the galls met with no success; remains of insects were obtained but not in a condition which permitted of identification.

## 5. HYPOCOTYL AND STEM

In the one-day seedling a series of sections was cut in the short primary radicle and it was found that, although at the very base there is no indication of well-marked proto-phloem or protoxylem, a secondary adventitious root is already formed (text-fig. 44).

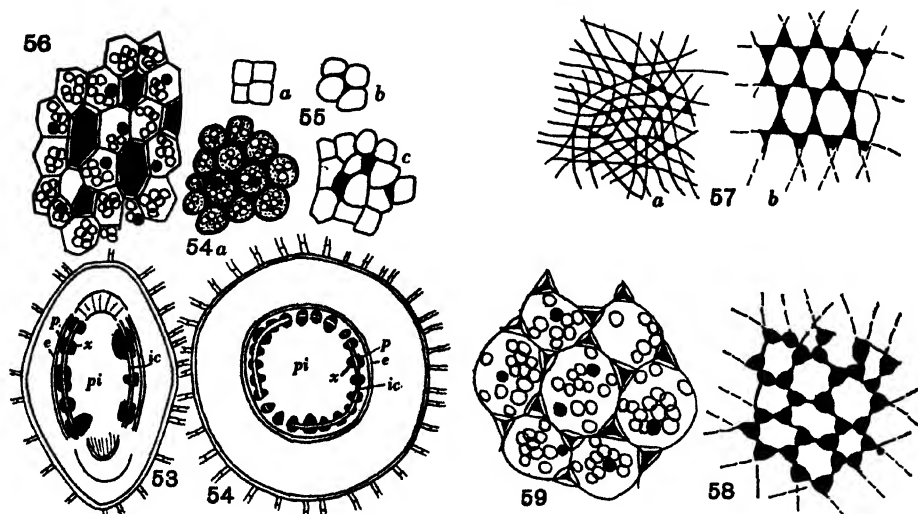
A little higher there is a distinct epidermal layer, which is devoid of hairs, and an endodermis that remains ill-defined throughout the life of the plant. There is a central xylem and three very indistinct phloem regions which are more evident a little higher where the transition to hypocotyl appears to take place (text-fig. 46). At this level a primary adventitious root has already penetrated almost to the epidermis; this latter



TEXT-FIGS. 44-52. Stem and hypocotyl. 44. Transverse section, extreme tip of primary root with single adventitious root (*ar*). *rc*=root cap. 45. Transverse section, primary root. *x*=xylem, *p*=phloem, *e*=endodermis. 46. Transverse section, base of hypocotyl with most advanced adventitious root (*ar*) and hairs (*h*). *ep*=epidermis, *p*=phloem, *x*=xylem, *e*=endodermis. 47. Transverse section, hypocotyl higher up. *vb*=vascular strand, *ep*=epidermis. 48. Transverse section, hypocotyl still higher. *p*=pith, *vb*=vascular strand, *e*=epidermis. 49. Transverse section, hypocotyl with two adventitious roots. *rc*=root cap, *ps*=periblem, *pl*=plerome. 49*a*, epidermis opposite adventitious roots (at *a* of text-fig. 49). *b*, epidermis in between adventitious roots (at *b* of text-fig. 49). 50. Transverse section, hypocotyl with adventitious roots in 1st stage. *c*=cortex, *x*=xylem, *d*=dermatogen, *rc*=root cap, *ep*=epidermis. 51. Transverse section, hypocotyl with adventitious roots, 2nd stage. 52. Transverse section, hypocotyl with two pairs of adventitious roots. *r*<sub>1</sub>=1st pair, *r*<sub>2</sub>=2nd pair.

now bears the hairs that are such a characteristic feature of the hypocotyl. Still higher up the hypocotyl the central xylem tissue breaks up into three separate bundles which subsequently divide into still smaller bundles until a ring is formed (text-fig. 48). This ring is repeatedly broken later at different levels wherever adventitious roots develop. In the 5-day seedling further development in the region of the adventitious roots has taken place and air spaces are being formed in the cortex. Another feature is the shape of the epidermal cells: this is dependent upon their position, those opposite the roots

being almost cubical whilst elsewhere they are rectangular, modifications which may be correlated with the pressures caused by the outgrowing roots (text-fig. 49 *a, b*). The various sections indicated that there is a strong tendency for the adventitious roots to arise opposite each other in pairs, one member of a pair arising just before the other (text-figs. 49–52). At still higher levels the adventitious roots continue to arise, the cells of the pith occupy a larger area and have small air spaces between them, and there is also an interfascicular cambium which marks the initiation of secondary thickening (text-fig. 53). The process of secondary thickening, however, is not very rapid at this stage. Towards the top of the hypocotyl, where there is a complete ring of vascular bundles, we find an interfascicular cambium, but it has not become active (text-fig. 54). The origin of the air spaces in the *cortex* takes place as follows: the cells, which are not arranged in distinct radial rows, are originally cubical or rectangular; later they round



TEXT-FIGS. 53–59. Stem and hypocotyl. 53. Transverse section, hypocotyl with two adventitious roots high up. *e*=endodermis, *pi*=pith, *ic*=cambium, *p*=phloem, *x*=xylem. 54. Transverse section, middle region of hypocotyl: lettering as in text-fig. 53. 54*a*. Pith cells of same with triangular air spaces (in black). 55. Origin of air spaces (marked in black) in cortex of hypocotyl. *a*, 1st stage; *b*, 2nd stage; *c*, 3rd stage. 56. 4th stage. 57. Origin of air spaces (black) in pith. *a*, 1st stage, low power; *b*, 1st stage, high power. 58. 2nd stage. 59. 3rd stage.

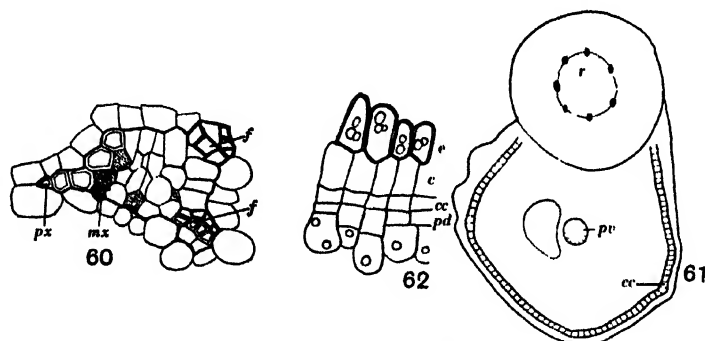
off and break away from each other except for single points of contact. This suggests that there is some dissolution of the middle lamella, or else that the walls become more mucilaginous and so do not adhere (text-fig. 55*b*). Just above the outgrowing adventitious roots the cells of the cortex exhibit another new feature. This is a more extensive mucilaginous thickening of the cell wall in those parts where it is adjacent to an air space. This extra thickening is laid down within the cells, and in view of its restriction to areas of wall opposite air spaces, it may be suggested that it is the direct result of some of the materials present in the sap coming into closer contact with the internal atmosphere and being deposited as a result of a chemical change, probably involving oxidation (text-fig. 56). As the plants become older and the cells more widely separated the exposure to air is more general and the thickening becomes deposited around the whole of the cells.

In the 5-day seedling, at the level of the second group of adventitious roots (text-fig. 52), the method of origin of the characteristic triangular air spaces (text-fig. 59) of



the *pith* may be observed. In the primary condition the cells in transverse section are commonly rectangular or occasionally polygonal, but they soon begin to round off at the corners with the result that the pith has the appearance shown in text-fig. 57*a*, the cells under the high power being arranged as in text-fig. 57*b*. This stage is followed by some retraction at the corners (text-fig. 58); finally, above the region of root development deposition of a material takes place along the edges of the triangles so that we get the appearance seen in text-fig. 59.

In text-fig. 60, which is a drawing of a single vascular strand from just above the region of root development, it can be seen that the protoxylem is well marked and that the metaxylem is just beginning to form. The cambium is not distinct but it becomes more obvious at a later stage. The next phase in the development of the hypocotyl begins on or just before the fifth day after liberation and concerns the formation of the cork cambium. Its position in the hypodermis would be due, on Priestley's hypothesis (1922), to the fact that there is no well-marked endodermis, and hence the epidermis acts as the 'blocking' layer. Text-fig. 61 represents a diagram of a section cut near the base of a hypocotyl, in which it will be noted that a cork phellogen is



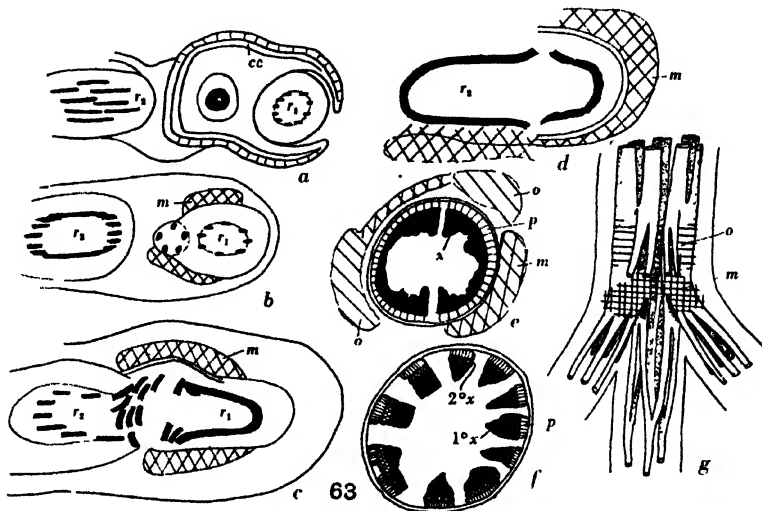
TEXT-FIGS. 60-62. Stem and hypocotyl. 60. Drawing of vascular bundle in hypocotyl just above the roots. *mx*=metaxylem, *px*=protoxylem, *f*=fibres. 61. Cork formation in hypocotyl *r*=root, *cc*=cork cambium, *pv*=procambial strands. 62. Cork formation in hypocotyl. Drawing of portion of text-fig. 61. *c*=cork cells, *cc*=cork cambium, *pd*=phellogen, *e*=epidermis.

present so that cork formation must begin very near the base: by the 7th day it extends about half-way up the hypocotyl, so that the course of development is from base to apex. Text-fig. 62 is a drawing of a small portion showing the phellogen, cork and phellogen in relation to the epidermis.

Text-fig. 63*a-f* illustrates a series of sections through the point of emergence of two roots from the hypocotyl of a 5-day seedling in order to demonstrate more clearly the method of origin and the behaviour of the vascular strands. A feature to which attention must be drawn is the development of groups of cells with dense mucilaginous contents at the sides of the roots near their point of departure from the central stele (text-fig. 63*b-d*). The sections also show that one root of a pair originates before the other in much the same way as the leaf traces originate (cf. earlier). Shortly above the origin of the uppermost pair of roots the two half-rings of vascular material split up into separate bundles with some secondary xylem but with very little secondary phloem (text-fig. 63*f*). The development of secondary tissue only proceeds to a limited extent because the main growth in thickness is brought about in quite another manner. In addition to the areas of mucilaginous tissue it was also observed that immediately above the point of origin of a root one could find a zone of cells containing a tannin-like material. This was especially pronounced in the case of roots arising above the primary pair. Text-fig. 63*g*

represents a solid reconstruction of this region based on the data presented by the various transverse sections.

In the 26-day seedling of text-fig. 8 a transverse section across the stem below the first leaves showed cortex and pith with small air spaces, but with no thickening as yet on the parts of the walls bounding these spaces. Both phloem and endodermis were ill-defined and there was no development of cork cambium. Immediately below the cotyledons, however, a cork cambium and two layers of cork cells could be seen, whilst there were also traces of an interfascicular cambium. About one-third of the way down the now elongated hypocotyl the interfascicular cambium was still not complete, but there were three layers of cork cells. Two-thirds of the way down the hypocotyl the interfascicular cambium was complete and there were four layers of cork cells. Longitudinal sections showed that elongation of the hypocotyl was primarily due to extension

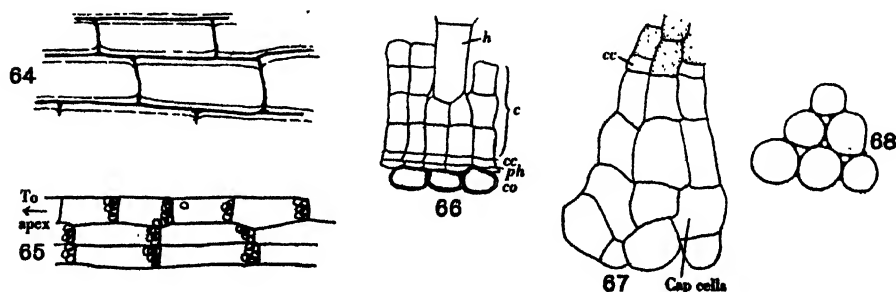


TEXT-FIG. 63. Stem and hypocotyl. *a*, lowest section of a series illustrating the behaviour of vascular strands on emergence from the hypocotyl. *cc*=cork cambium, *r*<sub>1</sub>, *r*<sub>2</sub>=successive adventitious roots. *b*, 2nd section. *m*=mucilaginous area. *c*, 3rd section. *m*=mucilaginous area. *r*<sub>1</sub> has united with the hypocotyl. *d*, 4th section, stelar region only. *m*=mucilaginous area. *r*<sub>1</sub> and *r*<sub>2</sub> have both united. *e*, 5th section, stelar region only. *m*=mucilaginous area. *o*=tannin region, *p*=phloem, *x*=xylem. *f*, 6th section, above the roots, stele only. Secondary thickening present in phloem (*p*) and xylem (*x*). *g*, solid reconstruction of vascular tissue in hypocotyl with two pairs of adventitious roots. *m*=mucilaginous area, *o*=tannin region.

of the cells of the different tissues. In these sections the parenchymatous cells were all regularly rectangular and presented no unusual features, but the xylem vessels had annular, spiral or reticulate thickenings. The pith cells exhibited a double band along the vertical, but not on the horizontal, walls, and it was evident that these markings were due to the triangular air spaces (text-fig. 64). One of the most striking features, however, was the distribution of the starch grains in the layers immediately outside the endodermis. The regularity of their arrangement (text-fig. 65) suggests that they may function as statolith organs, and in this respect they may be comparable to the starch sheath of the pneumatophores (cf. p. 512). Text-fig. 66 shows a drawing of the outer tissues and the cortex from the lowest region of the hypocotyl. There are four layers of cork and one of phelloderm, and the hypocotyl hairs are being shed as a result of the

cork development. It is at this stage that the hairs begin to wither and fall off, and there would seem little doubt that it is associated with the development of the cork. At the very base of the hypocotyl the cork cambium is apparently more deeply seated, but this is perhaps a fictitious appearance and may be due to the presence of the root-cap cells of the short primary root (text-fig. 67). Another feature to which attention must be drawn is the gradual increase in thickness of the walls of the cortical cells as one proceeds from the inner layers to the periphery. This can be explained if the outer cells of the cortex are regarded as being in closer contact with the external atmosphere than those nearer the centre, but it is all part of a biochemical problem which requires further investigation.

The seedling of text-fig. 9 was probably somewhat older because cork formation had begun in the short portion of stem below the first leaves, although it did not extend the whole way round the stem. As soon as the phellogen forms and the first division has taken place, the cells of the epidermis lose their contents and die. The pith cells in the middle region of the hypocotyl do not show the characteristic thickening



TEXT-FIGS. 64-68. Stem and hypocotyl. 64. Pith cells of 26-day seedling in longitudinal section 'showing banding caused by triangular air spaces. 65. Longitudinal section, cells immediately outside endodermis of hypocotyl of 26-day seedling showing distribution of starch grains. 66. Outer layers from lowest part of hypocotyl. *c*=cork, *cc*=cork cambium, *co*=cortex, *h*=hair base, *ph*=phellogen. 67. Deep-seated cork cambium (*cc*) at very base of hypocotyl. 68. Pith cells from stem of 'woody' seedling of text-fig. 9.

completely round the triangular air spaces but only in the angles (text-fig. 68). In the seedling of text-fig. 11 there was a band of fibres developing in small patches outside the secondary phloem. This marks the termination of active division in the primary ring of bundles and initiation of the secondary ring whereby growth in thickness is brought about. Secondary thickening could be observed in seedlings of the age shown in text-fig. 13: in these it is present in the hypocotyl and the internode above, and at this stage all the hypocotyl hairs have been shed. Boodle & Fritsch (1905) record the fact that secondary thickening in this genus is due to successive rings of extra-fascicular cambium arising in the pericycle outside the ring of limiting fibres and beneath the endodermis. In text-fig. 69 is shown a central pith with a ring of vascular bundles in which the xylem has remained more or less distinct, whilst outside the secondary phloem there is first a discontinuous ring of fibres, then a layer, one to two cells thick, of parenchyma, and next in order, a narrow zone of the second xylem ring, the second cambial ring, the second phloem ring, and on the extreme outside a second ring of limiting fibres. A more advanced stage of this process is seen in text-fig. 70, where four distinct stelar rings are depicted and a fifth is just beginning to develop; in some parts, however, the rings do not appear to extend completely round the stem but merge with the ring below. It is clear that a stem of this character should form an extremely interesting object for a

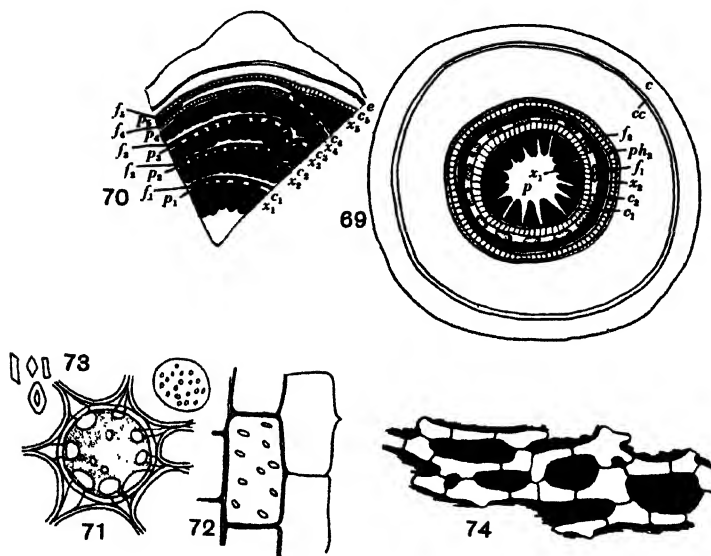
study of cambial development, especially since secondary thickening begins quite early. The problems to be solved are:

(1) What determines cessation of growth in any given ring? It cannot be the development of the fibres, because they may appear at the same time as the cambium. It may be some external factor, such as the onset of the dry season.

(2) What determines the initiation of meristematic activity in the new cambium?

(3) What determines the position of the new cambium?

Van Tieghem (1898) has recorded that in stems of 88 mm. radius there may be fifty-five stelar rings and in stems of 42 mm. radius there may be thirty, and he suggested that they may be formed annually, but the evidence from the present study, in which it has been noted that the secondary ring appeared relatively early, suggests that this hypothesis may not be correct: the formation of rings is perhaps more closely related to the alternation of wet and dry seasons.

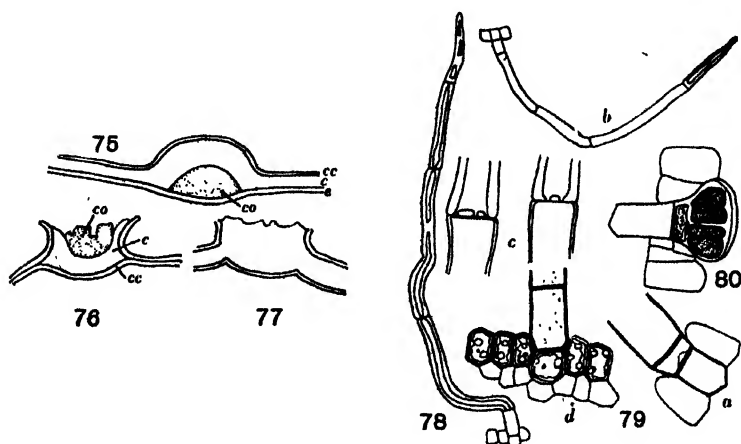


TEXT-FIGS. 69-74. Stem and hypocotyl. 69. Secondary thickening in the stem. *c*=cork, *cc*=cork cambium, *c*<sub>1</sub>=primary cambial layer, *c*<sub>2</sub>=2nd cambial ring, *f*<sub>1</sub>=1st fibre ring, *f*<sub>2</sub>=2nd fibre ring, *p*=pith, *ph*<sub>2</sub>=2nd phloem ring, *x*<sub>1</sub>=primary xylem, *x*<sub>2</sub>=2nd xylem ring. 70. Secondary thickening in the stem, older stage. *c*<sub>1-5</sub>=successive cambial rings, *f*<sub>1-5</sub>=successive fibre rings, *p*<sub>1-5</sub>=successive phloem rings, *x*<sub>1-5</sub>=successive xylem rings, *e*=endodermis. 71. Pith cell with thickening. 72. Longitudinal section, pith cells with pits on vertical walls. 73. Calcium oxalate crystals from pith. 74. Mature cortical cells of hypocotyl (air spaces black).

At the stage when secondary thickening begins one also finds further thickening of the walls of the pith cells taking place, a process that begins at the periphery of the pith in the neighbourhood of the protoxylem and proceeds centripetally. The thickenings are associated with the points of contact of adjacent cells, as may be seen in text-fig. 71, but the thickening is not uniform; unbordered pits are left in the thickened membrane, these pits appearing not only on the transverse but also on the longitudinal walls (text-fig. 72).

An examination of the seedling shown in text-fig. 14 indicated that cork formation began in the third internode from the apex, whereas the first traces of secondary thickening were usually to be found in the fourth internode. These tropical trees grow fairly rapidly, but in the absence of any real resting season there is no means of relating

the development of either cork or secondary thickening to a particular season of the year. Lower down, and nearer to the hypocotyl, the pith cells frequently contain crystals of calcium oxalate (text-fig. 73). In a section through the hypocotyl of one seedling (text-fig. 14) the cortex was fully developed (text-fig. 74), and it is typical of the mature cortical cells that they are no longer round but are elongate and irregular in shape. The cortex of the stem differs from that of the roots in that the cells are arranged more or less irregularly from a very early stage, and hence the air spaces also are irregular. The mechanical support cells which are to be found in the cortex of the roots are absent from the stem (text-fig. 92): this fact may be associated with the absence of pressure, other than atmospheric, on the aerial parts, although the hypocotyl must be exposed to some additional pressure from the flood water. An alternative hypothesis is that the mechanical cells are associated in some way with biochemical responses that bring about the deposition of the thickening material only in the underground parts.



TEXT-FIGS. 75-80. Stem and hypocotyl. 75. 1st stage in lenticel formation. *c*=cork, *cc*=cork cambium, *co*=patch of cortical cells, *e*=epidermis. 76. 2nd stage in lenticel formation. *c*=cork, *cc*=cork cambium, *co*=patch of cortical cells. 77. 3rd stage in lenticel formation. 78. Hypocotyl hair. 79. Parts of a hypocotyl hair; *c*, pits and thickenings; *a*, *d*, basal cells. 80. Gland from hypocotyl.

From a study of living seedlings it would seem that lenticel formation begins between 25 and 30 days after liberation from the testa and soon after a layer of cork has been deposited all round the stem. The first stage of lenticel formation in the stem is shown in text-fig. 75, where it may be noted that the cork cambium grows down into the stem and cuts off a small patch of cortical tissue; the cells of this patch die and disintegrate soon after the first cork cells have been produced. Before disintegration is complete the epidermis is ruptured and the cortical cells are exfoliated as further divisions in the cork cambium take place (text-fig. 76). We do not know what determines the places where the cork cambium will grow in and cut off the cortical cells, but a solution might be forthcoming from experimental work. The adult structure is seen in text-fig. 77: all the dead cortical cells have disappeared and the lenticel is filled by cork cells that have rounded off. The stem lenticel is therefore of the *Sambucus* type (Haberlandt, 1884) without any closing layers.

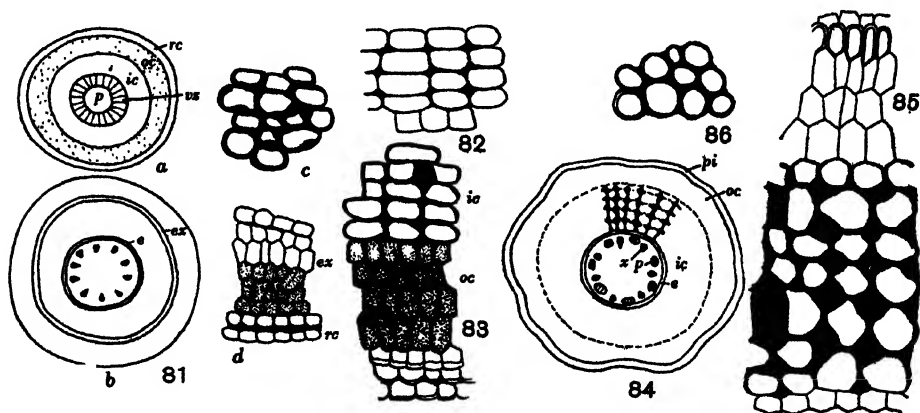
The characteristic hairs of the hypocotyl are of considerable morphological interest. From their position, and the way in which they are arranged, pointing up the stem, it has been supposed that they may be concerned with the establishment of the seedling

in the soil. The hairs are multicellular (text-fig. 78), and the walls of the terminal cells are invariably much thickened. There are distinct pits in the wall separating a cell with thickened walls from one with unthickened (text-fig. 79c): these pits are not always present between two of the thickened cells. The walls of the basal cell or cells never show any thickening, and this suggests that these hairs are really water-absorbing hairs, the absorption being carried out by the unthickened basal cells. Further support for this view is vouchsafed by the relatively slow development of the adventitious roots together with the absence of any root hairs. At the time when cork formation begins and the hairs therefore cease to function, e.g. 5–7-day seedlings, at least one or more of the lateral roots is reasonably well developed and able to absorb food materials.

One final feature to be noted in the hypocotyl is the occasional presence of glands in the epidermis. These have a short basal cell and a flat multicellular head, but they differ slightly from those of the leaves and cotyledons in that the subbasal cell is considerably elongated (text-fig. 80).

## 6. Roots

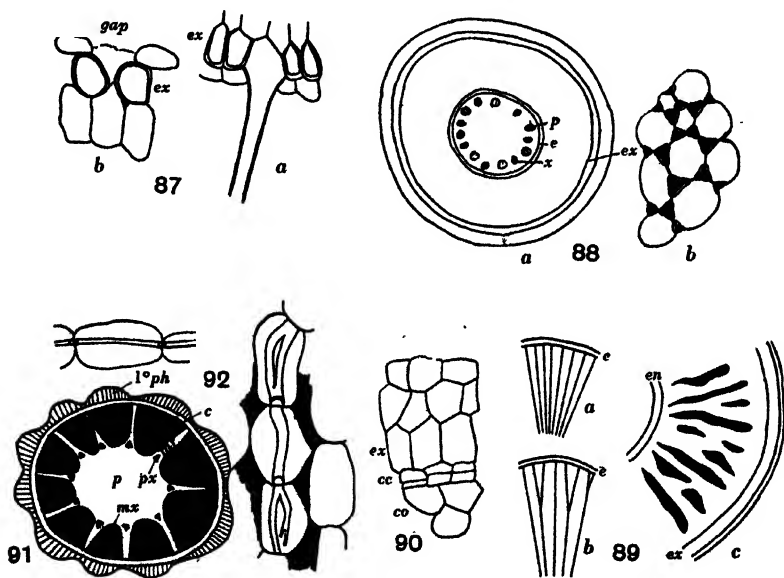
*A. Primary adventitious roots.* The early stages were studied in a 7-day seedling (text-fig. 4). A section near the root tip showed some layers belonging to the root cap, which readily break off (text-fig. 81d), then an outer cortical zone, in which the cells



TEXT-FIGS. 81–86. Primary adventitious roots. 81. *a*, transverse section, near root tip. *ic*=inner cortex, *rc*=root cap, *oc*=outer cortex, *p*=pith, *vz*=vascular zone. *b*, transverse section, farther back. *e*=endodermis, *ex*=exodermis. *c*, pith cells. *d*, exodermis (*ex*) and root cap (*rc*) from text-fig. 81*a*. 82. Origin of air spaces in inner cortex. 83. Origin of air spaces in inner cortex at a later stage (*ic*). *oc*=outer cortex. 84. Transverse section, root with air spaces in cortex. *e*=endodermis, *ic*=inner cortex, *oc*=outer cortex, *pi*=piliferous layer, *p*=phloem, *x*=xylem. 85. Drawing of part of section showing air spaces. 86. Pith cells of same section.

are closely packed together, followed by an inner cortical zone in which the cells begin to separate from each other, and finally a central ill-differentiated vascular zone (text-fig. 81*a*). At the growing apex the cells of the cortex are regularly rectangular and are arranged in rows that radiate out from the stele. The endodermis is not well defined, and outside the exodermis there are several layers of cells (text-fig. 81*b*, *d*). Even at an early stage there is a difference in shape between the cells of the inner and the outer cortex, those of the outer zone being polygonal rather than rectangular (text-fig. 83). Shortly behind the apex the cells of the inner cortex begin to round off and air spaces develop and enlarge (text-fig. 82). Somewhat further behind the apex one has the appearance illustrated in text-fig. 84, where there are radial rows of cells

and air spaces. Some of the outer cortical cells have divided radially and there may also have been a few tangential divisions. A more detailed drawing is seen in text-fig. 85 where it may be noticed that the walls of the exodermal cells have become slightly thickened. It can be seen, therefore, that the origin of air spaces in the cortex of these roots is a much more regular process than it is in the hypocotyl or stem. At this early stage the cells of the pith have also rounded off, thus producing the characteristic triangular air spaces with the additional thickening on the walls adjacent to the air spaces (cf. p. 499 and text-fig. 86). In these extremely young roots there are very occasional root hairs which appear to arise from the exodermis (text-fig. 87*a*); sometimes the exodermis may be broken by gaps (text-fig. 87*b*), although these may represent places where root hairs have been broken off. The proximal end of the roots, where they emerge from the hypocotyl, has the structure represented in text-fig. 88*a*. The air spaces of the cortex are not well developed and are largely triangular but those of the pith are quite typical (text-fig. 88*b*). The small air spaces in the cortex are probably associated with the pressure exerted by the surrounding tissues of the hypocotyl during the passage of the root through them. The release of this pressure, however, does not immediately result in an expansion of the cortical cells and the appearance of air spaces.



TEXT-FIGS. 87-92. Primary adventitious roots. 87. *a*, root hair arising from exodermis (*ex*). *b*, gap in exodermis (*ex*) providing passage for solutes. 88. *a*, transverse section, root at proximal end. *e*=endodermis, *ex*=exodermis, *p*=phloem, *x*=xylem. *b*, pith cells with air spaces from same root. 89. *a*, diagram of radial rows of cells in cortex. *e*=exodermis. *b*, diagram of radial rows of cells in cortex showing division into two rows at a later stage of development. *e*=exodermis. *c*, transverse section, root of 26-day seedling showing cleavage of rows and air spaces. *en*=endodermis, *ex*=exodermis. 90. Beginning of cork formation in the root. *co*=cork cambium, *co*=cortex, *ex*=exodermis. 91. Secondary thickening. *c*=cambium, *mr*=medullary ray, *mx*=metaxylem, *px*=protoxylem, *1°ph*=primary phloem, *p*=pith. 92. Mechanical cells of the cortex with thickening rods.

We have seen above that the cells of the cortex are arranged in radial rows, and that air spaces arise through the rounding off of the cells. There are relatively few subsequent tangential divisions among the cortical cells, but much elongation of the individual cells takes place with the result that a considerable strain is placed upon the cell rows and

sooner or later they buckle, thus leaving large radial air spaces far bigger than those found in the stem or hypocotyl. Such cell divisions as do occur take place in a radial direction, and in that case a single row divides to give two rows (text-fig. 89*b*). In the oldest roots the original row arrangement may be greatly obscured due to the breaking away and deflexion of the rows. In the 7-day seedling there is no cambial development, not even near the base of the root, but one can distinguish bundles of xylem alternating with less distinct patches of phloem, fourteen being the number of strands most frequently encountered. Interfascicular cambium and secondary xylem were first seen in the 26-day seedling (text-fig. 8) near the base of the largest root, where there was also some incipient cork formation (text-fig. 90). About half an inch from the proximal end of this same root there was no evidence of secondary thickening or of cork formation, although buckling of the cell rows had taken place in the cortex with the production of air spaces (text-fig. 89*c*). In the fleshy type of seedling one of the characteristic features is the development of large stout roots with more numerous colls in the various tissues and also with a much greater development of air spaces in the cortex: otherwise the morphology of the stout and thin roots is identical. The stout roots are commonly wrinkled both horizontally and longitudinally, and it would seem that wrinkling is related to the lack of uniformity between the elongation of the cortical cells and rate of cell division in the phellogen.

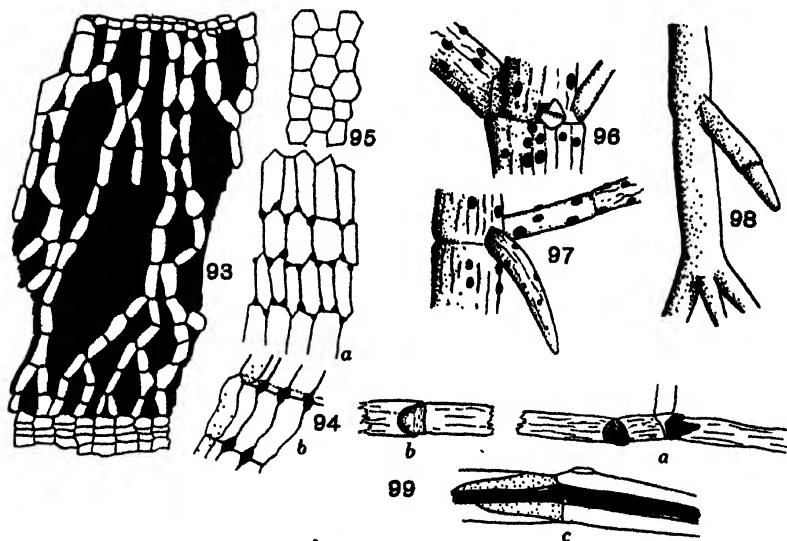
The next stage in the development of the primary adventitious roots is seen in a seedling of the type illustrated in text-fig. 13, in which a section from near the base of a root shows large air spaces extending from the stele out to the cork cambium. There is also some development of secondary phloem and xylem, secondary xylem being developed mainly opposite the patches of primary phloem, thus leaving rather broad medullary rays opposite the patches of primary xylem. There is relatively little production of secondary phloem in comparison with that of secondary xylem (text-fig. 91). Another new feature is the development of thickening bars in some of the cortical cells, which must provide some mechanical support to the loose tissues. The thickenings begin as faint whitish bands which become more clearly defined as additional material is laid down, and it is noticeable that they commonly occur throughout a whole radial row of cells, each band apparently running on from cell to cell. This is obviously a more useful mechanical system than one in which there is an equal number of single isolated cells (text-fig. 92).

Some of the roots which grow out from the base of the hypocotyl do not develop to any extent and probably soon die. These may be regarded as the primary adventitious roots: others, which tend to arise slightly higher up the hypocotyl, become true lateral horizontal roots and are normally larger, more wrinkled and less prone to bear secondary roots and rootlets. It is from these that the pneumatophores arise.

*B. Horizontal roots.* A section through one of the developing horizontal (cable) roots belonging to the seedling depicted in text-fig. 14 shows that there is a greater proportion of cortex to stele than there is in the primary roots, and also that there is rather less secondary xylem, though otherwise the structure is fundamentally the same. Text-fig. 93 shows a portion of the cortex of such a root; this illustrates the great development of air spaces and one can also see the remains of the initial row arrangement. In a longitudinal section the plates of cortical cells have a very characteristic appearance (text-fig. 94); the cells do not fit closely into each other all round, but small triangular air spaces are left at the angles; these will only permit of a relatively small degree of intercommunication between both sides of a plate. This means that air flow can take place readily in a longitudinal direction, but circular air flow around the root must take place against a resistance. It will also be observed that the cortical cells are elongated along the radial plane whereas the cells of the pith are polygonal or else elongated in the longitudinal plane (text-fig. 95). The horizontal roots, from which the pneumatophores



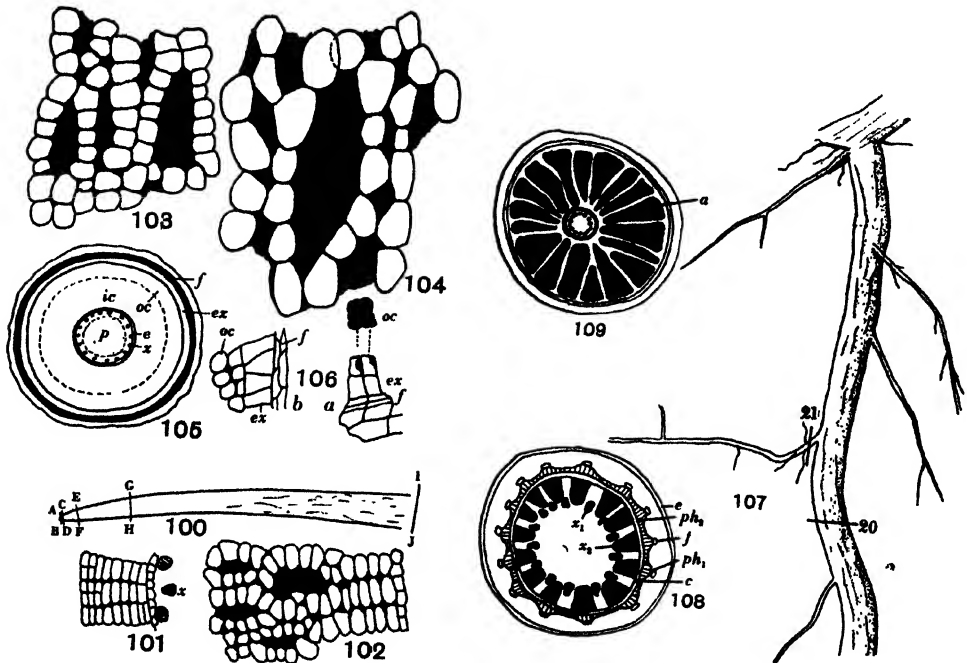
develop, arise from successively higher nodes as the ground level rises. They often arise between a pair of branches (text-figs. 96, 97), and there is occasionally some indication in such places that there should have been a pair of roots, because on the opposite side of the stem to the existing root one may find aborted vascular traces and a disintegrated cork layer. The apices of the lateral roots must be relatively susceptible to injury, although this is not serious because a new growing point develops shortly behind the destroyed apex and continues to grow in more or less the same direction (text-fig. 98). In mature roots this may have happened more than once and traces are left of each dead end, while there is also a slight 'kink' in the root where the new apex arose (text-fig. 99). Though it is easy to see how damage might be caused to the pneumatophores it is not so easy to understand how these underground lateral roots come to suffer. A feasible explanation is that the ends are bitten off by crabs when the roots penetrate their burrows.



TEXT-FIGS. 93-99. Horizontal (cable) roots. 93. Portion of cortex of well-developed root. 94. *a*, longitudinal section of cortex; *a* portion of a radial plate. *b*, solid diagram of part of a radial plate. Dotted parts are cells in transverse section. 95. Longitudinal section, pith cells. 96, 97. Horizontal roots arising from same node as branches. 98. Injured root with new apex. 99. *a*, root that has been injured in two places. *b*, injured root with old dead end. *c*, longitudinal section of injured root showing behaviour of vascular strand.

Text-fig. 100 shows a drawing of a horizontal root that was examined in detail for its developmental stages. Near the apex the rectangular cells of the cortex are arranged in regular rows and the innermost layer is meristematic, divisions taking place in a tangential direction. Farther back behind the apex the cortical cells begin to round off and rows of air spaces make their appearance (text-fig. 101); with further growth in size of the cells the rows begin to separate and the air spaces are considerably enlarged (text-fig. 102). This process is continued (text-fig. 103) until the final phase begins, which is concerned with elongation of the cells (text-fig. 104); it is at this stage that the cork cambium makes its appearance. Sections from near the apex have the appearance shown in text-fig. 105. There is first an outer zone of large cells without contents, which may form part of the root cap; underneath is a layer of cells which have undergone some compression, though farther back these cells expand and form a layer outside the exodermis. Beneath this zone there is a single row of cells with but few contents (the

exodermis, or 'protoderm' of Troll & Dragendorff); within this is the outer cortex which is composed of small cells closely packed together and with dense contents (text-fig. 106). The inner cortex consists of the radial rows of cells with the developing air spaces, and it would seem that the air spaces gradually extend into the outer cortex with increasing distance (e.g. age) from the apex of the root. The number of xylem groups is not distinct, but from counts made farther back it appeared that there are fourteen such groups alternating with ill-defined patches of phloem. The early development of the cork cambium in both the primary and horizontal roots indicates that these



TEXT-FIGS. 100-109. Horizontal (cable) roots (100-106) and anchoring roots (107-109). 100. Drawing of horizontal root which was examined for developmental stages at marked spots. 101. Transverse section root at CD with incipient air spaces in inner cortex.  $x$ =xylem. 102. Transverse section, root at EF showing cortex with enlarged air spaces. 103. Transverse section, root at GH showing air spaces of cortex. 104. Transverse section, root at IJ showing air spaces of cortex. 105. Transverse section, root at AB.  $e$ =endodermis,  $ex$ =exodermis,  $f$ =zone of compressed cells,  $ic$ =inner cortex,  $oc$ =outer cortex,  $p$ =pith,  $x$ =xylem. 106.  $a$ , part of section from text-fig. 105 showing outer cortex ( $oc$ ), exodermis ( $ex$ ) and compressed cells ( $f$ ).  $b$ , exodermis ( $ex$ ), compressed cells ( $f$ ) and outer cortex ( $oc$ ) farther back from position CD. 107. Portion of an anchoring root. 108. Transverse section, stele at point 20 of text-fig. 107.  $c$ =cambium,  $e$ =endodermis,  $f$ =fibres,  $ph_1$  and  $ph_2$ =primary and secondary phloem,  $x_1$  and  $x_2$ =primary and secondary xylem. 109. Transverse section, lateral at point 21 of text-fig. 107.  $a$ =air space.

roots cannot play a great part in the absorption of food materials. There is also a complete absence of root hairs, which is probably correlated with either or both of the following factors: (1) early development of cork, (2) frequent inundation of the soil. About 3 in. behind the apex there is still only a cork cambium, which has arisen beneath the exodermis, but no cork cells; there is also an interfascicular cambium in the process of development. In the particular root studied the most recently formed pneumatophore was found just behind this region, and beyond it further development had taken place. This comprised some secondary phloem and xylem and also two or three layers of cork.

Characteristic thickening bands were beginning to form in some of the cortical cells, whilst in the outermost layers of the pith thickening of the cells was also taking place. At this stage the pith exhibits the triangular air spaces, but the bounding walls are not thickened as they are in the stem and primary root, a phenomenon which may be due to the greater distance from the external atmosphere via the pneumatophores. This might well result in a lower oxygen concentration and hence less likelihood of oxidation products being formed. Brenner (1902), when he states that the pith of *A. tomentosa* (= *A. nitida*) lacks spaces in the 'earth' roots, is probably referring to the horizontal roots, but the present investigation indicates that air spaces are to be found.

An attempt was made to determine whether the relative proportions of stele and cortex to total root radius could be related to soil type. The results are set out in Table I. These figures do not indicate any significant correlation, but the roots were

TABLE I

Site	Total radius mm.	Radius of cortical area mm.	Cortex % of total	Radius of stele mm.	Stele % of total	Cortex stele ratio
1. On surface of sandy mud by Rio Cobre	3.5	1.5	42.8	2.0	57.2	0.75
2. Peat glade	2.5	1.5	60.0	1.0	40.0	1.5
3. Peat glade	4.5	2.0	44.4	2.5	55.6	0.8
4. Peat glade	3.5	2.0	57.1	1.5	42.9	1.33
5. Sand-spit	2.5	1.5	60.0	1.0	40.0	1.5
6. Sandy salina	3.0	2.5	83.3	0.5	16.7	5.0
7. Low sand-dune (roadside)	3.5	1.5	42.8	2.0	57.2	0.75
8. Careening Cay in <i>Halimeda</i> sand	5.0	2.0	40.0	3.0	60.0	0.66
9. Coral and sand, surface roots	3.5	2.5	71.4	1.0	28.6	2.5
10. Coral, surface roots	3.0	2.5	83.3	0.5	16.7	5.0

probably not of comparable age so that some correction might have to be made; even so it is very doubtful whether any correlation with soil or habitat would result. There is some slight indication from these figures that surface roots from coral areas tend to have a higher proportion of cortex to stele; this may be associated with the fact that they do not encounter any pressure from the soil. When the necessity for anchorage is considered the proportion of stele to total area is not very high, but this is counterbalanced by the wide horizontal spread of the roots.

C. *Anchoring roots.* The anchoring roots are generally more or less simple and unbranched. The root depicted in text-fig. 107 was examined at the points marked 20 and 21: at the former some of the rows of cortical cells possessed thickening rods (text-fig. 92). There were fourteen primary xylem groups with relatively little secondary thickening, while compared with the horizontal roots there was a much smaller stele, less secondary thickening and wider rays opposite the protoxylem groups. Bundles of pericyclic fibres were also present outside the phloem (text-fig. 108). The smaller stele may perhaps be correlated with the almost permanent waterlogging that these roots must endure as compared with the horizontal roots. There is an increasing size of stele in the following order: deep waterlogged anchoring roots, subsurface horizontal roots, exposed pneumatophores. A section through the side root at the place marked 21 in text-fig. 107 showed a small stele and large air spaces in the cortex with some of the cells stiffened with the characteristic simple lignified support rods. The cork cambium was just beginning to form beneath the exodermis so that the structure is not fundamentally different from

that of the anchoring root (text-fig. 109). Börgesen (1909) described the anchoring roots as arising from the base of the pneumatophores; he also considered that they were the absorbing organs, but it seems clear that this is not correct.

D. *Pneumatophores*. These roots, which are said to be negatively geotropic, vary considerably in size, but they may reach a length of 35 cm. and a diameter of 8–10 mm. Apart from the maximum length attained there is also the proportion of the pneumatophore above the soil: this varies considerably but seems to be largely dependent upon the rate of accretion, the greater the rate the smaller the portion above the soil. The relative proportions of pneumatophores in different soils is expressed approximately in Table II. Text-fig. 110 shows the aerial portion of a single pneumatophore, and it may

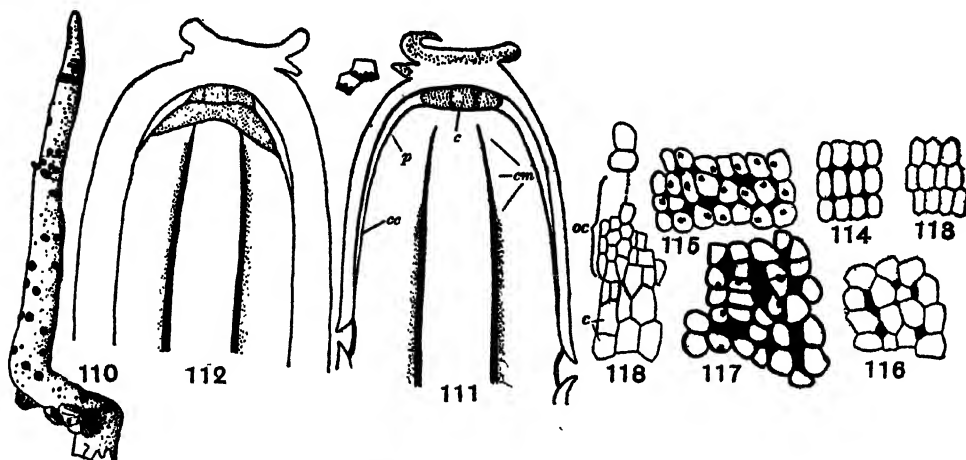
TABLE II

	Amid coral boulders %	In peat %	In mud %	In sand-spit %
Proportion exposed	100	75	50	25
Proportion in earth	0	25	50	75

be compared with others illustrated in text-figs. 149 and 157. The lenticels do not extend to the very tip nor are they formed at all until the pneumatophore appears above the ground. Thus, in the case of pneumatophores arising from surface horizontal roots amid coral boulders lenticels will be found along their whole length. The restriction of lenticels to the aerial portion can be seen in text-figs. 149 and 157, although with continued accretion a certain number of the lenticels near the base subsequently become covered.

There appear to be two kinds of pneumatophores which may be described briefly as the *smooth* and the *rough* types, and they have both been briefly described already by Brenner (1902). The rough type has numerous lenticels, which project markedly from the surface (text-fig. 140), and on drying the root wrinkles and becomes spongy; the smooth type possesses fewer lenticels, which do not project (text-fig. 139), and the root does not wrinkle on drying but remains firm and compact. There are certain other morphological differences which will be described later. Brenner (1902) reported that some of his smooth pneumatophores did not possess lenticels, but as he was examining preserved material it is more than probable that he may have had specimens which had only just penetrated above the soil surface. I was unable to find any pneumatophores in Jamaica which were above the surface and yet lacked lenticels. Brenner considered that the rough type arose from deep horizontal roots and represented an older condition, whereas the smooth type developed nearer the trunk and arose from shallower horizontal roots. This interpretation cannot be regarded as correct because one may find adult pneumatophores of both types, and those coming from nearer the stem are often of the rough type. The two categories seem to be related rather more closely to the soil type, as was also suggested by Brenner, who thought that the smooth ones developed wholly in air or else in a loose slime, whilst the rough came from deep soils or else developed wholly in water. On this basis he considered that the rough pneumatophores were associated with environmental conditions where the necessity for gaseous interchange was greatest. Observations made on herbarium specimens suggested that the smooth type is associated with loose sand and rapid accretion or else with exposure to the air. The latter alternative is confirmed to some extent by the fact that the smooth type are firm whereas the rough pneumatophores are spongy to the feel; even the spongy type, however, are much firmer in the portions above the soil, so that exposure to the atmosphere may be correlated with firmness of the tissues although it is also the more youthful portion. The rough type, on the other hand, appear to be associated with

compact sand, firm mud, peat or persistent immersion in water. In a section through the rough type (text-fig. 111) the outer cork layer is relatively thin and consists of only two to three layers of cells, whilst the starch zone, or statolith organ (cf. p. 523), is confined to the area of the root cap immediately around the columella, although isolated starch grains do occur in the cork cap. The starch sheath in the endodermis does not become evident until some distance below the apex, but lenticels develop very early and are numerous. Thickening of the pith cells begins near the periphery of the pith at about 3 in. behind the apex and at a point where the cortex is already fully developed. One may find characteristic branched thickenings in the cortical cells at this level, but they are not confined to isolated swollen cells. On staining with ruthenium red the cortex takes up a uniform red colour whilst the cork barely stains; in the smooth type the cortex stains much darker with ruthenium red and the cork also stains fairly heavily. It is possible that the cork is chemically different in the two types. In the



TEXT-FIGS. 110-118. Pneumatophores. 110. Above soil surface portion of a pneumatophore. 111. Longitudinal section, rough type of pneumatophore. 112. Longitudinal section, smooth type of pneumatophore. At top 2 cells from columella with starch grains. Dotted areas mark starch regions. *c*=columella of root cap, *cc*=cork cambium, *p*=protoderm (exodermis), *cm*=meristematic layer in cortex. 113-117. 1st to 5th stages in development of air spaces in cortex. 118. Portion of transverse section just below apex. *c*=cork, *oc*=outer cortex.

smooth type the cork sheath is much thicker and consists of from eight to twenty layers of cells: the apical starch statolith area is more extensive and the endodermal starch sheath begins much nearer the apex. Another very characteristic feature of this type is the differentiation within the inner cortex of large isolated mechanical cells (text-figs. 126, 127), whilst the cells of the outer cortex also nearly all tend to be thickened with rods. This suggests that the smooth pneumatophores develop under conditions where there is a more immediate necessity for internal support, e.g. areas of rapid accretion. Brenner (1902) gives a detailed morphological analysis of the two types, but his data suggest that he may have taken young unexposed pneumatophores for the smooth type.

Text-fig. 111 also illustrates the arrangement of the different tissues. At the apex there is the cork covering, the outer layers of which break off successively with age, arising from a meristem that is indistinguishable from that of the root cap. The pneumatophore differs from the horizontal root in possessing this apical cork cap, a feature which is associated with the aerial roots of other mangroves. Priestley (1922) has shown that cork formation is concerned with the deposition of suberin in the presence of air together

TABLE III  
(After Brenner)

	No. of cell layers		
	Cork sheath	Phloem	Xylem
Rough: Apex	7-10	4-5	15
Middle	6-12	4-7	10
Base	10-11	4-8	12
*Smooth: Apex	10-20	5-8	14
Middle	10-20	10-14	33
Base	15-35	8-14	38

\* In Brenner's paper the 'glatte' or smooth pneumatophores are figured correctly in Plate VI, but I believe the data in the table are transposed with the 'höckerige' or rough pneumatophores. In the table above this has been remedied.

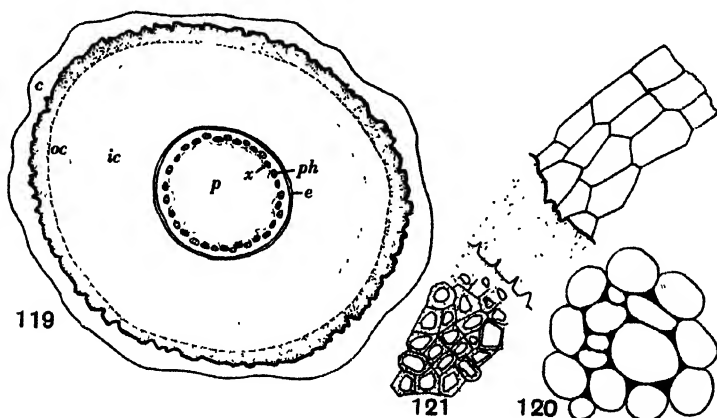
with the accumulation of sap behind a morphological barrier, and cork development in these roots may thus be associated with their great exposure to the atmosphere. One young pneumatophore that had been collected before it appeared above the surface did not have a cork cap but possessed the normal root cap, whilst Troll & Dragendorff (1931) also found that in unexposed aerial roots of *Sonneratia* there was no corky covering. These authors suggest that the function of the cork cap is to prevent the apex from drying up. Other aerial roots are known which have a corky covering over the root cap e.g. *Pandanus*, *Rhizophora*, although in the case of the aerial roots of orchids there is no such cap but it can be regarded as replaced by the dead cells of the velamen. It would seem, therefore, that the cork root cap is associated with exposure to the air and dry conditions, and it remains to be determined experimentally whether this is an adaptation to the environment or whether it is an inevitable biochemical change that takes place in such surroundings. It can also be suggested that the development of the pneumatophores is correlated with the extensive cork covering of the under-surface roots, thus almost completely inhibiting interchange with the soil atmosphere.

Beneath the cork sheath there is the ordinary root cap, the meristem of which merges into the apical meristem of the root; delimiting the root meristems is not easy, as Tischler (1910) has already noted, because the regions of dermatogen and periblem extend transversely. It is also evident that, as in *Sonneratia* (Troll & Dragendorff, 1931), the growing region of the periblem extends back some way because the inner layer of the cortical meristem is still active some distance behind the apex. Outside the procambial strands is the endodermal sheath with the starch grains, whilst outside the cortex is the exodermis which merges into the dermatogen-periblem complex near the apex. Cork formation begins just outside the exodermis, though near the apex there is a layer of root-cap cells between the cork and the exodermis. Cork cambium is first distinguishable a little way behind the apex so that the actual cork cap is perhaps morphologically distinct, because the apical cork tissue appears to be composed of root-cap cells which have become suberized. This development of cork from the root-cap meristem opens up an interesting problem concerning the relationship of root cap to cork tissue; alternatively, it may be asked whether there is a true root cap to these roots. If there is no root cap then the roots are anomalous, but the fact that cork is only formed in the presence of an atmosphere containing adequate oxygen suggests that the calyptogen and phellogen may be morphologically homologous, and that subsequent changes in the cells they each produce is determined by the composition of the atmosphere to which they are exposed.<sup>1</sup> Cork formation is also connected with the accumulation of sap in cells behind

<sup>1</sup> This cannot be the whole story because in some soils the soil atmosphere must contain sufficient oxygen to enable cork formation to occur. It is a point, however, that is worth further investigation.

a definite morphological barrier, which in most roots is provided by the endodermis. In the horizontal and primary roots the exodermis acts as this barrier, but there is no apparent barrier near the apex of the pneumatophores, although farther back cork may form beneath an ill-defined exodermis which is later exfoliated. The morphological changes that take place in a young pneumatophore when it is just beneath the soil surface and as it emerges demand further study, and it was unfortunate that more material was not brought back.

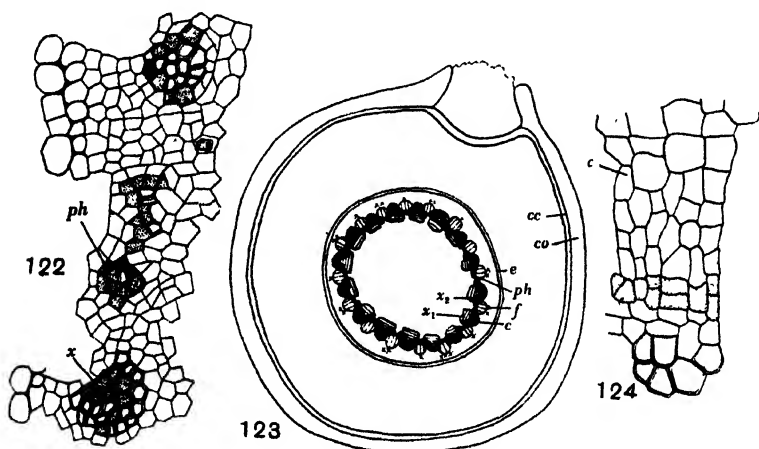
The development of air spaces in the cortex is illustrated in text-figs. 113–117. In text-fig. 113 the rectangular meristematic cells are arranged in regular rows; the cells round off (text-fig. 114) and then the rows begin to separate, due to expansion of the cells (text-fig. 115), until the row arrangement becomes somewhat indistinct (text-fig. 117). The rounding off and dissolution of the middle lamella takes place primarily along the radial walls and rarely affects the tangential walls. Growth in length of the pneumatophore takes place not only by means of the apical meristem but also through elongation of the cells of the different tissues, this latter process probably being quite



TEXT-FIGS. 119–121. Pneumatophores. 119. Transverse section behind apex. *c*=cork, *oc*=outer cortex, *ic*=inner cortex, *e*=endodermis, *p*=pith, *ph*=phloem, *x*=xylem. 120. Pith cells of text-fig. 119. 121. Outer cortex and cork of text-fig. 119.

as important as the former. Near the apex, where there is no distinct cork cambium because the cork cells appear to arise from the root-cap cells, a transverse section has the appearance of text-fig. 118. A little farther behind the apex a section across a pneumatophore has the appearance of text-fig. 119, the pith cells showing signs of some oblique divisions whereby their number is increased. The vascular strands average about fifteen, and although Brenner (1902) regards the endodermis as distinct it is not always readily recognizable. In no case could casparian strips, such as Troll & Dragendorff (1931) have recorded for *Sonneratia alba*, be seen. The pith cells round off quite near the apex to give the triangular air spaces (text-fig. 120). Normally the cells of the outer cortex become progressively smaller and smaller towards the periphery (text-fig. 118), but sometimes the small outer cells are so filled with some material (probably tannin) that they have the appearance shown in text-fig. 121. Near the apex phloem and xylem are not readily distinguished from each other because they are both arranged more or less on the same radius. Typical phloem and xylem bundles from near the apex are shown in text-fig. 122. About  $\frac{1}{2}$  in. behind the apex the interfascicular cambium makes its appearance and isolated pericyclic fibres appear opposite the protophloem bundles. The cambium commonly arises first below the protophloem and may be absent opposite

the protoxylem until much later. A similar development has also been described by Troll & Dragendorff (1931) for *Sonneratia*. Lenticels are present and are fully developed, but the cork cambium is not always well marked as may be seen from text-fig. 124. In the cortex the cells have expanded, and in the smooth pneumatophores the differentiation of the large mechanical cells has begun at this level or perhaps even earlier (text-figs. 125, 126). At a later stage the actual thickening rods begin to develop, and it is clear that they arise as ingrowths of the cell wall, initially at points of contact with neighbouring cells. The same relationship is true of the thickened cells in the horizontal roots, the rods originating at the ends of each cell where it adjoins neighbouring cells (text-fig. 92). A causal relationship is evident, but further biochemical, X-ray or Röntgen ray analyses are required in order to establish the exact nature of the changes that take place (text-fig. 127). It will be noted that these large cells are isolated in the pneumatophores and are not united into series as they are in the horizontal roots. The final stage in development of those large strengthening cells is seen in the cortex about



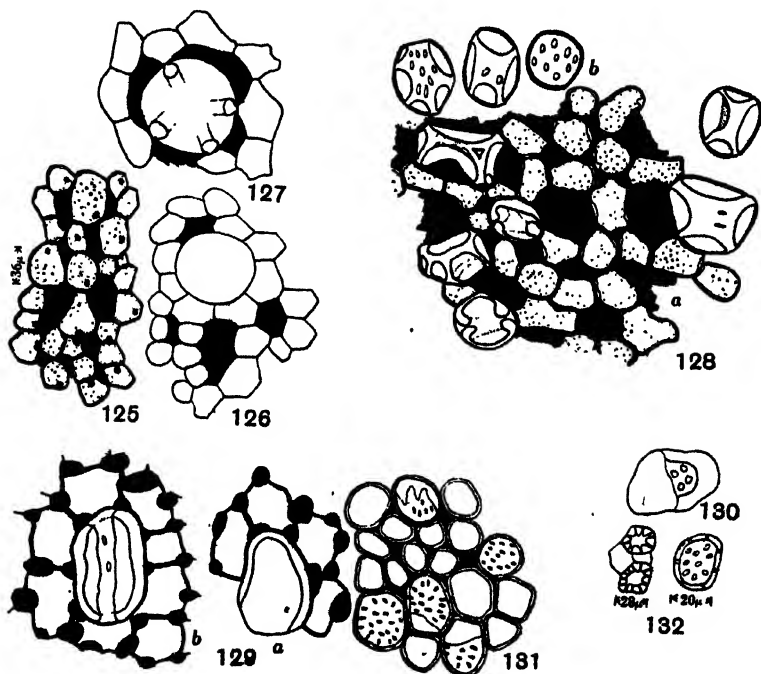
TEXT-FIGS. 122-124. Pneumatophores. 122. Phloem (*ph*) and xylem (*x*) from near the apex in transverse section. 123. Transverse section showing beginning of secondary thickening. *co*=cork, *cc*=cork cambium, *c*=cambium, *e*=endodermis, *f*=fibres, *ph*=phloem, *x*<sub>1</sub>=primary xylem, *x*<sub>2</sub>=secondary xylem. 124. Cork (*c*) and ill-defined cork cambium (dotted).

2 in. behind the apex (text-fig. 128*a*). Development of these cells appears to begin at the periphery of the cortex and to proceed centripetally, though ultimately the largest cells will be found nearest the stele. Some of these isolated cells are drawn in text-fig. 128*b*, and it will be noted that the thickening rods may be perforated with simple pits. These idioblasts, as they may be called, have much the same appearance in longitudinal section (text-fig. 129); it will also be noted that the cells of the cortical plates are similar to those in the cortex of the horizontal and primary roots. The idioblasts have been observed by other workers (e.g. Börgesen, 1909; Schenck, 1889; and Brenner, 1902), and the latter has termed them, incorrectly I think, trichoblasts. In the primary cortex of *A. tomentosa* (*A. nitida* var. *tomentosa*?) Brenner describes the idioblast thickenings as being three-armed, although it is clear that they are often more highly branched in *A. nitida*. Brenner also states that they are simple or one-branched in the secondary cortex, but no confirmation of this statement could be obtained for *A. nitida* as I never found a secondary cortex that was sufficiently far developed (cf. p. 523).

When normal cells of the cortex are juxtaposed one finds pore plates of the type mentioned by Brenner (text-fig. 130). He also described hair-like cells with internal



spiral thickenings on the borders of large intercellular spaces, but no such cells were found in my material. About  $\frac{1}{2}$  in. behind the apex, thickening of the pith cells begins as usual from the periphery, and farther back we find the appearance seen in text-fig. 131. In the middle region of a pneumatophore the pericyclic fibres are well developed and abut on to the endodermis (text-figs. 132, 133). Text-fig. 134 shows a transverse section from the middle region of the pneumatophore illustrated in text-fig. 110. There is considerable secondary thickening, medullary rays are prominent opposite the protoxylem bundles, and the pericyclic fibres form a complete ring. There is no evidence of the appearance, in either the horizontal roots or the pneumatophores, of successive rings of stelar tissue comparable to those of the stem. Text-fig. 135 represents a drawing

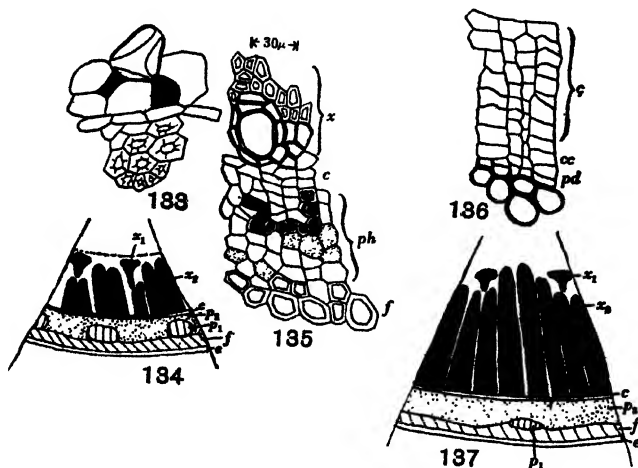


TEXT-FIGS. 125-132. Pneumatophores. 125-127. 1st to 3rd stages in development of idioblasts. 128. *a*, mature idioblasts in cortex. *b*, isolated idioblasts with pits in thickening. 129. *a*, *b*, idioblasts in longitudinal section. 130. Pore plate in normal cortical cell. 131. Thickened pith cells. 132. Pericyclic fibres.

of a portion of the secondary vascular tissue and the pericyclic fibres, whilst text-fig. 136 illustrates the phellogen, phelloderm and cork from the middle region of a pneumatophore. In a large smooth pneumatophore the layers of cork cells in this region may be as many as 40-45. Text-fig. 137 shows a transverse section from about soil level: there has been further secondary growth, and the unthickened cells of the cortex are beginning to collapse and become brown in colour. This collapse is rendered obvious externally by the appearance of wrinkles and the loss of firmness. In text-fig. 138 is seen a drawing of part of the fully developed cortex.

Text-figs. 139 and 140 illustrate the differences between lenticels from smooth and rough pneumatophores. In the one case there is no projection above the general surface whilst in the other it is considerable, probably because the cork is thinner (8-10 cells) and the cork cambium in the lenticel more active: in the smooth type the cork skin is

much wider (40 cells) and the cork phellogen does not appear to be so vigorous. Text-fig. 141 shows a drawing of part of a young lenticel, and it is clear that gaseous diffusion must be slow, especially through the phellogen. At first there is a thin outer cork sheath, but this, together with the end cells of the cork rows, becomes thrown off, a process Schenck (1889) was not able to recognize, although he thought that it must occur. With increasing age secondary cork phellogens may be laid down underneath to form closing layers, so that these lenticels (text-figs. 142, 143) differ from those of the stem in being of the *Aesculus* type (Haberlandt, 1884). Brenner (1902) noted this development of secondary cork cambium in the lenticels, and he observed that it might descend some considerable distance into the cortex.

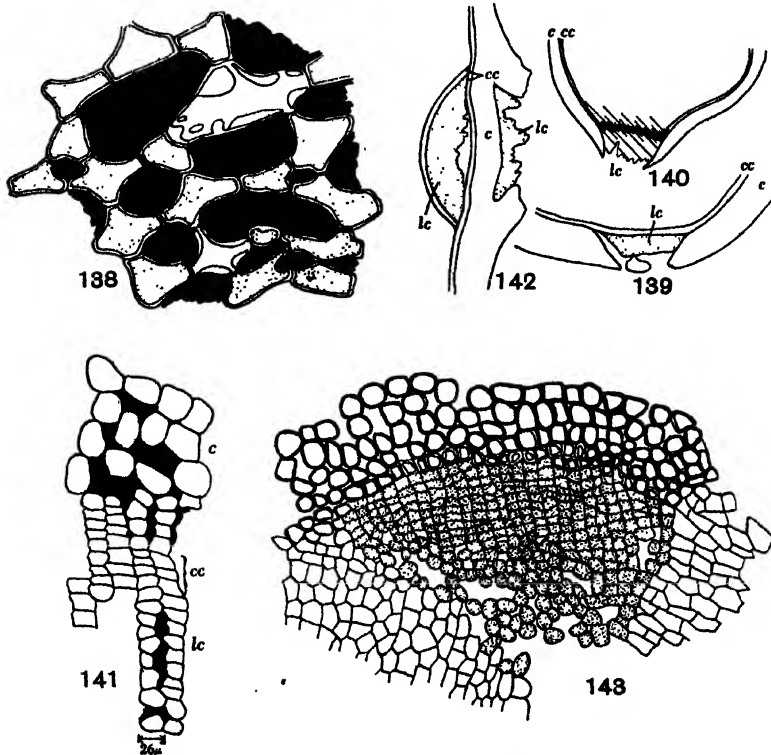


TEXT-FIGS. 133-137. Pneumatophores. 133. Pericyclic fibres, endodermis and cortex. 134. Transverse section from middle of aerial portion of pneumatophore. *e*=endodermis, *f*=pericyclic fibres, *p*<sub>1</sub>=primary phloem, *p*<sub>2</sub>=secondary phloem, *c*=cambium, *x*<sub>1</sub>=primary xylem, *x*<sub>2</sub>=secondary xylem. 135. Drawing of secondary vascular tissue seen in text-fig. 134. *f*=pericyclic fibres, *ph*=phloem, *c*=cambium, *x*=xylem. 136. Cork (*c*), cork cambium (*cc*) and phelloderm (*pd*) of same section as text-fig. 134. 137. Transverse section, pn. at soil level. *e*=endodermis, *f*=pericyclic fibres, *p*<sub>1</sub>=primary phloem, *p*<sub>2</sub>=secondary phloem, *c*=cambium, *x*<sub>1</sub>=primary xylem, *x*<sub>2</sub>=secondary xylem.

In the rough pneumatophores there is a phenomenon which is associated with or responsible for the wrinkling. The first stage occurs at the same time as the cortical cells begin to separate from each other. The cork cambium becomes both depressed and compressed and ceases to give rise to regular rows of cork cells, so that one finds the type of structure seen in text-fig. 144. In the older parts of the root the depression is even more pronounced (text-fig. 145), perhaps because of fewer radial divisions in the depressed cork cambium associated with continued cell elongation in the cortex, but the cork cells are still being produced, though irregularly. The wrinkling is a feature that is not properly understood and it requires further investigation. It may represent an immature lenticel that aborts or it may be a purely mechanical phenomenon. The present author is inclined to the latter view.

Whilst the majority of the pneumatophores are simple, occasionally one may find some that branch once or twice throughout their length: an anatomical investigation shows that the branching is due to death or injury of the original apex. It is probable that such injury is largely caused by the crabs that inhabit the swamps. Troll & Dragendorff (1931) have reported a similar phenomenon for the pneumatophores of

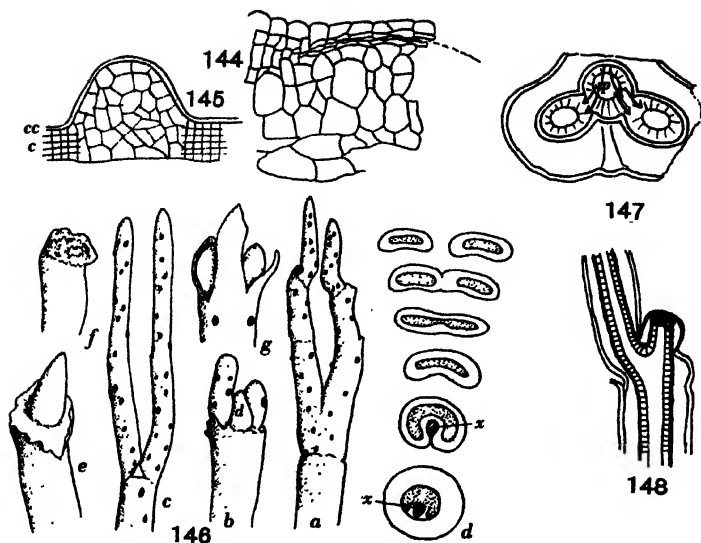
*Sonneratia* and Tischler (1910) for those of *Avicennia officinalis*. In the case of *Sonneratia* the new growing point, which takes up the same direction as the original apex, arises from the pericambial region: unfortunately, sufficiently young enough stages were not obtained from the pneumatophores of *Avicennia nitida* to indicate the tissue of origin. New apices develop fairly rapidly because a bush that had all its pneumatophores decapitated in July possessed well-developed fresh apices by the middle of September in the same year. Text-fig. 146*a-g* illustrates various stages in the regeneration process. The root in text-fig. 146*e* was cut across and the two new branches arising from the



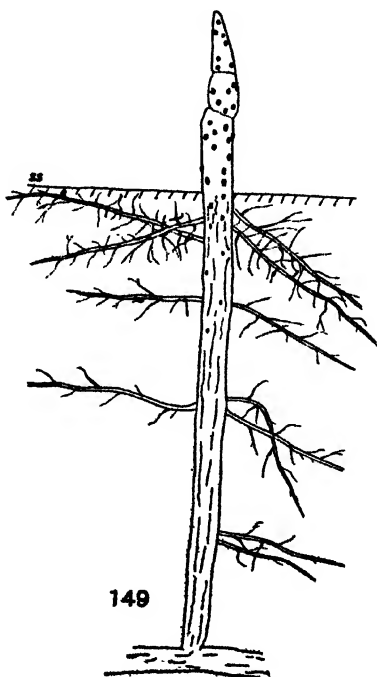
TEXT-FIGS. 138-143. Pneumatophores. 138. Cortex in transverse section at soil level of pneumatophore. 139. Diagram, lenticel of a smooth pneumatophore. *c*=cork, *cc*=cork cambium, *lc*=lenticel cells. 140. Diagram, lenticel of a rough pneumatophore. Intensity of shading represents resistance to air-flow. 141. Drawing of part of a young lenticel. *c*=cortex, *cc*=cork cambium, *lc*=lenticel cells. 142. Transverse section, lenticel to show closing layer. *cc*=cork cambium, *c*=cork, *lc*=lenticel cells. 143. Drawing of a mature lenticel in transverse section.

original central axis are clearly shown (text-fig. 147). The root illustrated in text-fig. 146*a* and *d* was interesting because originally only one new apex arose from the wounded tip, but during the early stages of growth it bifurcated. This was the only example encountered in which bifurcation was not due to secondary growth from wounding. Text-fig. 148 pictures the origin of a secondary apex from a primary apex that has been wounded; the broken cork of the original root forms a frill where the new apex has broken through, whilst a thin layer of wound cork has developed over the dead apex.

Text-fig. 149 shows a drawing of a pneumatophore from the sand-spit in Hunts Bay where the rate of accretion is rapid. This results in the development of a whole series of absorbing roots at successively higher intervals as the level of the ground has been

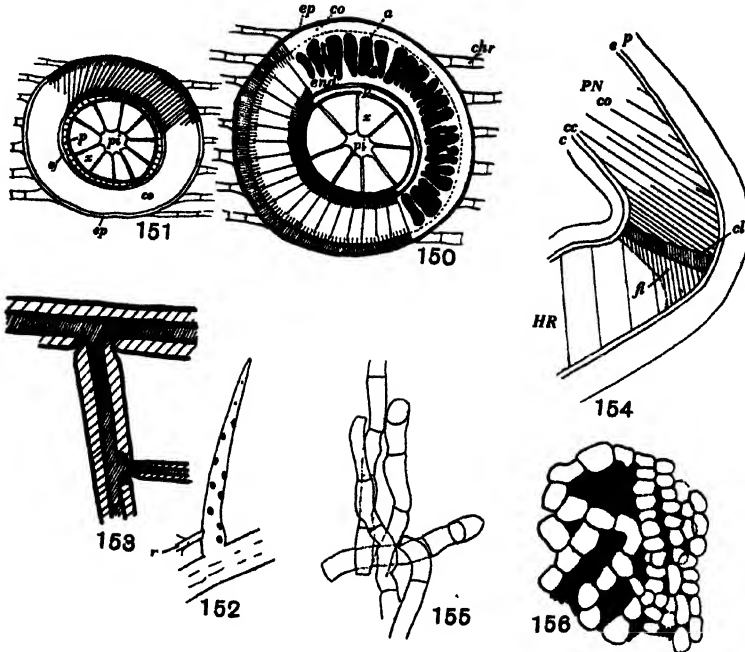


TEXT-FIGS. 144-148. Pneumatophores. 144. 1st stage in development of a wrinkle. 145. Transverse section, mature wrinkle. *c*=cork, *cc*=cork cambium. 146. *a-g*, pneumatophores showing regeneration with branching, *d* being a series of sections through *a* to show true bifurcation. *x*=dead apex. 147. Transverse section of root shown in text-fig. 146 *c*. *p*=pith. 148. Diagram illustrating origin of secondary apex from a wounded root.



TEXT-FIG. 149. Pneumatophore from sand spit in Hunts Bay.

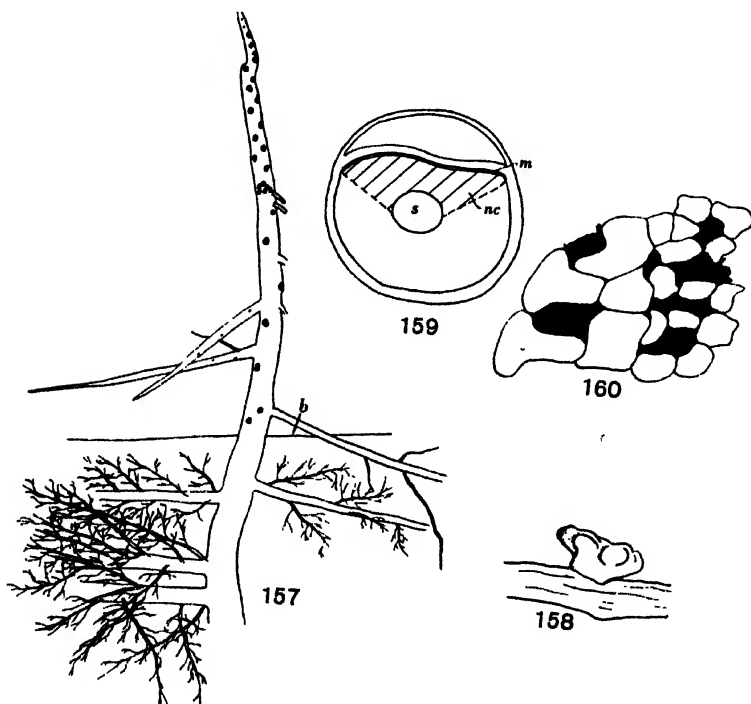
raised, the lower and older ones dying off. Some of the lower lenticels are now covered by a considerable depth of soil. The aerial portion was firm to the touch, but the subterranean portion was flaccid and spongy due to the collapse of all the cortical cells other than the idioblasts. In a section cut near the base (text-fig. 150) the cells of the outer cortex were closely packed and gaseous diffusion would be difficult; there are, however, considerable air-spaces in the inner cortex although these disappear in the part of the pneumatophore still within the horizontal root (text-fig. 151).



TEXT-FIGS. 150-156. Pneumatophores. \*150. Transverse section, base of pneumatophore of text-fig. 149. Half the section is shaded, the density of the shading representing resistance to gaseous diffusion. *a*=air spaces in cortex, *chr*=cortical plates in horizontal root, *co*=cortex, *end*=endodermis, *ep*=epidermis, *p*=phloem, *pi*=pith, *x*=xylem. 151. Transverse section, same root in the cortex of the parent horizontal root. Density of shading represents resistance to gaseous diffusion. Lettering as for text-fig. 150. 152. Drawing of a pneumatophore, absorbing root (*r*) and horizontal parent root. 153. Longitudinal section of text-fig. 152. Density of shading represents resistance to gaseous diffusion. 154. Diagram of one-half only of base of pneumatophore. The section stops at the xylem and no pith is shown: *HR*= $\frac{1}{2}$  horizontal root, *PN*= $\frac{1}{2}$  pneumatophore, *c*=cork, *cc*=cork cambium, *co*=cortex, *e*=endodermis, *p*=phloem. Density of shading represents resistance to gaseous diffusion. The most densely shaded band is the 'closing layer' *cl*, *f*=fibrous layer. 155. Cells from the 'fibre' zone. 156. Closing layer of absorbing rootlet and its point of contact with cortex of pneumatophore.

In text-fig. 152 is shown a pneumatophore and horizontal root that were investigated in order to ascertain the air-space relations at the point of origin of both a pneumatophore and an absorbing rootlet (*r*). As the pneumatophore emerges from the horizontal root its tissues are released from the pressure of the cortical plates of the horizontal root; as a result the cortical cells of the pneumatophore are able to expand so that one finds a characteristic sudden bulge at the base of these organs. The same phenomenon may also be seen in the anchoring roots. Text-fig. 153 shows a diagram of a longitudinal section cut through this specimen, and it will be noted that at the point of origin of

both pneumatophore and absorbing root there is an indentation of the cork from which a band of closely knit cells passes to the endodermis. The air spaces in this band are very small and gaseous diffusion cannot take place readily. An enlargement of half the pneumatophore base is seen in text-fig. 154, where it will be noted that outside the zone of closely packed basal cells, or *closing layer* as it may be called, there is a zone of loose cells which readily come apart in a section and look like multicellular fibres (text-fig. 155). There is a very sudden and marked transition from these fibres to the cortical plates of the horizontal root. The cork layers of pneumatophore and horizontal root fuse together,



TEXT-FIGS. 157-160. Pneumatophores and absorbing rootlets. 157. Pneumatophore from a peat soil. *b* = position of transverse section. 158. An abnormal abortive pneumatophore. 159. Transverse section, absorbing rootlet at point *b* in text-fig. 157. The development of secondary cortex (*nc*) is shown. *m* = meristematic zone, *s* = stele. 160. Drawing of cells of secondary cortex (right) where they abut on to cells of the primary cortex (left).

and there is a gradual increase in the percentage of air space as the pneumatophore emerges from the horizontal root. At the origin of the lateral rootlets the 'fibre' zone is absent, but the closing layer is present and abuts directly on to the laterally placed cortical plates of the pneumatophore; the transition from one to the other is distinct as may be seen from text-fig. 156.

Text-fig. 157 shows a pneumatophore from peat, and it will be noted that the numerous lateral absorbing rootlets are denser and confined to a narrow zone. There is evidently an inherent tendency in the pneumatophores to give rise to absorbing roots because in the peat soils they are frequently produced above the soil surface. Two such roots are seen in text-fig. 157, and although they are devoid of rootlets they possess lenticels. In this pneumatophore there was evidence of roots arising still higher up, but these had

died before reaching the soil surface. The production of absorbing roots is therefore not wholly related to soil accretion, and one must suppose that there is also an inherent genetic control; experimental work should be able to determine to what extent the one may modify the other. In the soil the absorbing roots appear to be plagiotropic, but when they grow out above the soil surface they are positively geotropic. If a change of tropism can take place in these roots they should form excellent material for a study of this phenomenon.

In an investigation of *Sonneratia alba* and *Avicennia officinalis*, Tischler (1910) thought that he could detect a difference between the apices of the horizontal roots and the pneumatophores. The horizontal roots were said to differ from pneumatophores in the absence of a starch sheath in the endodermal region, although they possessed the statolith organ in the columella of the root cap. In the pneumatophores there was no root cap and distinction of dermatogen, periblem and plerome was difficult, whereas in the horizontal roots there was a root cap and the meristems were distinct. In their reinvestigation of *Sonneratia*, Troll & Dragendorff (1931) could find no such distinction, both types of root possessing a root cap, though the pneumatophore had an additional cork covering to the root cap. There are, however, certain differences between the pneumatophores and the horizontal roots of *Avicennia nitida* which may be correlated largely with their relative positions in the soil.

TABLE IV

Pneumatophore	Horizontal root
Cork over apex	No cork over the apex
Secondary thickening begins very soon behind apex	Secondary thickening begins some way behind apex
Stele/cortex high	Stele/cortex low
Presence of lenticels	Lenticels absent unless root above soil surface
Isolated idioblast cells	Idioblast cells in rows
Thickenings of idioblasts—branched rods	Thickenings of idioblasts commonly simple

Another point in connexion with the pneumatophores is the statement made by Schimper (1891) and Troll & Dragendorff (1931) for *Sonneratia alba*, that the structure of the aerial portion is different to that of the soil portion. This is said to be seen principally in the size of the air spaces and also by the production in the aerial portion of a more extensive phelloderm, the cells of which are rich in chloroplasts. In *Sonneratia* the aerial portion also possesses a sheath of rounded cells (füllzellen) outside the phellogen which were responsible for the exfoliation of the cork layers. No such sheath was found in the pneumatophores of *Avicennia nitida*, nor was cork peeling observed except very near the apex. The larger air spaces in the subterranean portion are mainly due to the collapse of the cortical cells, and this is simply an age phenomenon. There was no evidence that they invariably collapsed in *Avicennia*, but there seems no doubt that there is some correlation between size of air space and position in the pneumatophore. Small air spaces and firmness are characteristic of the aerial portion, large air spaces and sponginess of the soil portion. Brenner (1902) suggests that this is related to the oxygen conditions, the basal portion being hydromorphic because of low oxygen, and the aerial portion aeromorphic because of the high oxygen concentration. In view of observations to be recorded later (cf. p. 525) it is doubtful whether this hypothesis provides an adequate explanation; it must be remembered that the aerial portion is younger than the soil portion, and the firmness may simply be associated with the stage of development. There was some slight evidence of phelloderm production in the aerial portions of the pneumatophores but not to the extent described by Troll & Dragendorff (1931) for the pneumatophores of *Sonneratia*.

Jost (1887) considered that the pneumatophores were positively aerotropic, whilst Karsten (1891) and later workers have regarded them as negatively geotropic. Tischler (1910) was the first to describe the area in the root cap with starch accumulation as a

statolith organ, and to show that when pneumatophores were laid horizontally the apex turned up into the vertical direction. In addition to the terminal statolith organ Tischler considered that the endodermal starch sheath acted in a similar manner up to a distance of about 10 cm. from the apex, an observation that was derived from experiments on pneumatophores of *Sonneratia*. Troll & Dragendorff (1931) have since argued that the statolith theory is not valid because there is a similar starch sheath in the horizontal roots. I have observed an endodermal starch sheath in the pneumatophores of *Avicennia nitida*, and a development very comparable to that described by Tischler for pneumatophores was found in the hypocotyl of a seedling (text-fig. 65). It is quite possible, however, that the starch sheaths in all these different structures are statolith organs; what we require to know is more about the mode of operation in these cases, but this is yet another problem that must wait for the future. Since the work of the earlier investigators much has been discovered about the part played by auxins in determining direction of growth, and it would seem essential that any future investigation on the growth behaviour of these different types of root must be approached from this point of view. Another feature, which requires investigation, is the nature of the stimulus which determines where each pneumatophore shall arise. It must be supposed that the presence of pneumatophores is now an hereditary factor and, as such, is not susceptible of ready investigation, although it has been suggested earlier that they might have arisen as a result of the cork covering to the subterranean rootlets. This, however, may not be wholly true. A plant growing in the Cambridge Botanic Gardens is now four years old and has produced no pneumatophores. This may be because of the conditions under which it is growing, and it suggests that an experimental approach to the problem may not prove fruitless.

E. *Absorbing roots*. These commonly arise from the pneumatophores at a short distance beneath the soil surface: their density and proximity to each other, which depends on the rate of accretion taking place, is greatest in peat soils. When the horizontal roots lie on the surface the absorbing roots are then found on the anchoring roots. They are normally clothed with numerous rootlets which have neither root hairs nor a cork covering, so that the actual absorption takes place in these ultimate rootlets. A section through an absorbing root shows that it has the structure in miniature of an horizontal root including a layer of cork cells.

Sections through the bare root illustrated in text-fig. 157 at point *b* showed a phenomenon that has been described previously by Brenner (1902). This consists of the development of a deep secondary cork cambium which grows across the cortex and cuts off a considerable portion that subsequently dies. Underneath the secondary cork cambium and phelloderm there arises a secondary cortex: this differs from the primary cortex in the much smaller size of the cells and air spaces and also in the absence of any idioblasts. The distinction between the primary and secondary tissue is extremely distinct, as may be seen from text-figs. 159 and 160. Externally it is practically impossible to tell when this phenomenon has occurred until the outer dead cortex breaks down and becomes more or less rotten. No young stages were encountered, but it is clear that here too is an interesting problem in physiological anatomy.

Although the description of the morphology of *A. nitida* given above has aimed at being as complete as possible, it is more than evident that there are a number of extremely interesting and important problems that still remain to be solved. In view of the relatively rapid growth of these plants they should form very suitable material for further experimental morphological investigations.

## 7. FUNCTIONS OF THE PNEUMATOPHORES

Ever since these pneumatophores became known to botanists there has been speculation as to their function. Quite early they were regarded as organs for gaseous interchange



between the atmosphere and the internal tissues of the plant, although there has not been complete agreement as to the exact mechanism. On the one hand there is the theory which considers that the interchange is secured by means of simple diffusion; on the other hand there is Westermaier's theory (1900) that the pressure of water at the flood tide forces the air in the horizontal roots out to the surface via the pneumatophores, and then when the tide recedes fresh air is drawn in. This latter theory would demand mass streaming rather than diffusion, nor at any time have bubbles of air been observed coming out of the pneumatophores when the tide was flooding them. Furthermore, the anatomical investigation has shown that communication between the horizontal roots and the pneumatophores is not so free as might be imagined (cf. text-fig. 163 and below), and that very considerable pressures would be required in order to obtain mass flow. We may therefore conclude that diffusion is the normal means of gaseous interchange. Until 1930 no attempt was made to ascertain whether the pneumatophores carried out any additional function other than that of gaseous interchange, although it is true that certain workers considered that they might have a respiratory function. Some degree of root respiration, however, is only to be expected. If respiration is measured by the amount of carbon dioxide diffusing out through the pneumatophore, then the total respiration ( $R$ ) will have two components: (a) partial respiration of the pneumatophore and its absorbing roots ( $P$ ), and (b) partial respiration of the adjacent horizontal root ( $H$ ),

$$R = P + H.$$

If the respiratory function is important then  $P$  must form a high proportion of  $R$  (cf. p. 531).

The only thorough investigation of this problem is that by Troll & Dragendorff (1931) for the pneumatophores of *Sonneratia*. These workers were able to show that in addition to being organs of gaseous interchange the absorbing rootlets were produced and maintained on them at a more or less definite level below the soil surface; they were also capable of some respiratory activity.

A. *Gaseous interchange*. When the investigation of the soil conditions was carried out the analyses for the soil water-table showed that the concentration of oxygen was extremely low, and, furthermore, in the soil atmosphere the oxygen concentration was commonly less than half that in the external atmosphere (cf. Chapman, 1940). This means that the gaseous conditions under which the horizontal, primary and absorbing roots exist are not optimal.<sup>1</sup> It might be argued that as the roots are covered by an impermeable cork covering the conditions in the soil will have no effect on the respiratory activity of the plant. On the other hand, field observations showed that *Avicennia* plants in the middle of Gun Cay, which were growing well above the tide mark and whose roots were not in the permanent water-table, had produced no pneumatophores. There is also the case of the plant growing in the Botanic Gardens at Cambridge (cf. p. 423) where no pneumatophores have so far appeared. There therefore seems to be some relationship between the soil conditions and the appearance of pneumatophores, and although their production may be primarily controlled by a genetical factor (cf. p. 523), nevertheless external conditions appear able to exert a modifying effect. Another example of the action of the external environment was noted on the east shore of Lime Cay, where on one side the roots of a tree were permanently in water, and on the other side were in the *Halimeda* sand of the cay where the soil was much drier. On the sea (inundated) side the pneumatophores were extremely numerous, but on the cay (dry) side they were not abundant. It would seem that this is a problem that might be elucidated by experimental work.

<sup>1</sup> This must perforce remain an assumption until experiments have determined the maximum oxygen requirements of the roots.

There is some field evidence, therefore, that the pneumatophores are organs of gaseous interchange and that their presence is perhaps correlated to some extent with poor oxygen supply, especially in places where there is continual waterlogging. The next step in the investigation was an analysis of the atmosphere contained in the air spaces of the pneumatophores and horizontal roots. Pneumatophores were cut off and quickly immersed in a 1 : 1 strong salt solution and pure glycerine. They were then gently pressed, and as the bubbles of air came out from the cut end they were collected under a glass funnel filled with the same solution, the first few bubbles being discarded: sufficient gas for analysis was rarely obtained from a single pneumatophore, and two or three had to be treated in this manner. The gas was transferred from the funnel to a gas holder filled with mercury by means of a glass syringe (cf. Chapman, 1940), and on return to the laboratory was analysed by a Bonnier and Mangin apparatus. The results of the analyses are expressed in Table V.

TABLE V

(PN = pneumatophore; HR = horizontal root)

Site	Organ	% CO <sub>2</sub>	% O <sub>2</sub>	Site % O <sub>2</sub>	Site % CO <sub>2</sub>
Pool with no gas, Rio Cobre	PN	1.65	19.12	—	—
Pool with no gas, Rio Cobre	HR	1.62	19.18	—	—
Sand beach, Hunts Bay	PN	0.11	20.58	8.81	19.73
Mud + gas, Hunts Bay	PN	0.97	19.76	5.79	6.44
Fringe of glade	PN	0.32	20.03	5.67	8.08
Fringe of glade	HR	1.24	18.94	3.65	9.17
Open salina	PN	1.12	18.95	2.69	0.11
Open salina	HR	1.57	18.2	2.33	0.74
In peat swamp	PN	1.3	19.64	8.09	11.53
In peat swamp	HR	0.7	19.12	6.26	5.31

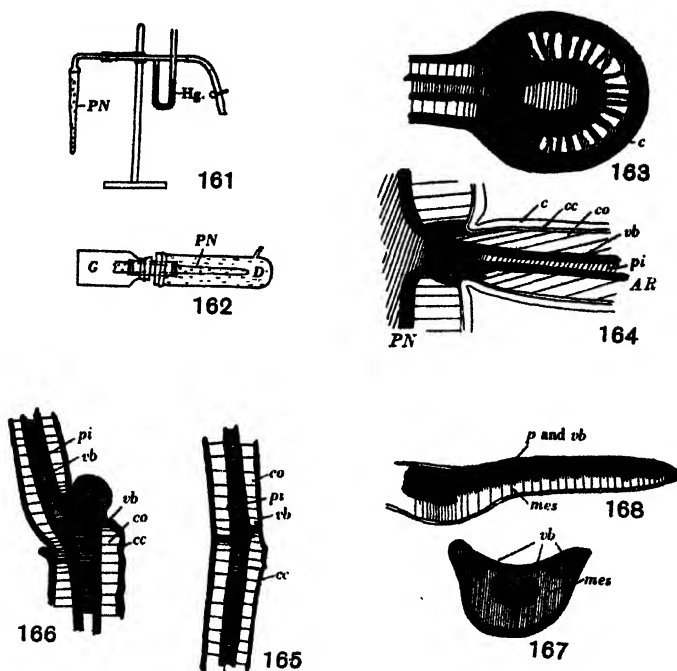
Two points at once emerge from these figures:

(1) The composition of the gas in the roots is very akin to that of the ordinary atmosphere and markedly different from the surrounding soil atmosphere of the site. In view, however, of the complete absence of lenticels on the underground horizontal roots and also in most of the subterranean parts of the pneumatophores, this is perhaps not surprising. Even supposing there had been a relationship between the soil atmosphere and that of the roots there would still remain the problem of how the gas diffuses across the water film that must surround these roots. The close correlation with the composition of the atmosphere offers quantitative support to the theory that these roots function as organs for gaseous interchange.

(2) There is no fundamental difference between the composition of the gas in the pneumatophores and that in the horizontal roots. Troll & Dragendorff (1931) found that there was a gradual increase in the carbon dioxide concentration the greater the distance from the pneumatophore, but only in my samples from the fringe and open salina did this obtain.

An attempt was also made to determine the nature of the relationship between lenticular and cuticular gaseous interchange. It might have been supposed that the thick cork covering would have completely inhibited any extra-lenticular exchange, but Troll & Dragendorff found that this was not entirely so. This point is also of importance in connexion with the suggestion that the cork coat is partially pervious to air. The apparatus used was similar to that employed by these workers (cf. text-fig. 161). Some of the experiments were carried out in the field, whilst others were performed on roots brought back to the laboratory, in which case not more than 1 hr. elapsed between the cutting of the root and the experiment. In view of the size of the cortical air channels it is not likely that they would have become blocked in this period. The pneumatophore

was taken, and after a fresh surface had been cut it was put into the reception end of the porometer tubing so that it fitted as tightly as possible without undue compression of the tissues. The join was sealed firmly with the aid of paraffin wax. Mercury was sucked up the graduated manometer tube *B*, the clip closed and the time was noted for the mercury to fall a given distance, this process being repeated until the recorded times were comparable. Troll & Dragendorff found that they could effectively seal the lenticels by treating them with chloroform, using any one of three methods: (a) touching



TEXT-FIG. 161. Apparatus for cuticular and lenticular exchange. *PN* = pneumatophore, *Hg* = mercury. 162. Apparatus for diffusion. *PN* = pneumatophore, *G* = gas chamber, *D* = diffusion chamber. 163. Transverse section, horizontal root at origin of pneumatophore to show resistances to gas flow and diffusion. *c* = cork. 164. Longitudinal section, pneumatophore and absorbing root to show resistances to gas diffusion. 165. Longitudinal section, injured horizontal root to show resistance. 166. Longitudinal section, injured pneumatophore to show resistance. 167. Transverse section, petiole to show resistance. 168. Transverse section, leaf to show resistance. In text-figs. 163–168 the degree of resistance to air flow is represented by the density of the shading. *c* = cork, *cc* = cork cambium, *co* = cortex, *mes* = mesophyll, *pi* = pith, *AR* = absorbing root, *PN* = pneumatophore, *p* = palisade, *vb* = vascular bundle.

each lenticel individually with liquid, (b) immersing the whole root in the liquid, (c) placing the root in the vapour. Of these, the first may be regarded as the most satisfactory because the second method will probably have some effect on the internal tissues via the cut end and may also affect the cork covering. The vapour may also be expected to affect the internal tissues and corky coat so that the limitations of these two methods must be borne in mind when considering the results. After the experiment each pneumatophore was removed, measured and the number of lenticels counted. The results are recorded in Table VI.

This table shows that with the exception of no. 4 the untreated pneumatophores recorded lower times than those which had been treated. The long time taken by no. 4

TABLE VI

No.	Treatment	Time for mercury to fall 4 cm.	Length of pneumatophore cm.	No. of lenticels
1	Untreated	4 min. 45 sec.	25	252
2	"	1 min. 15 sec.	12	108
3	"	2 min. 20 sec.	17	161
4	"	13 min.	5½	57
5	"	1 min. 1 sec.	28.9	124
6	"	7 min. 40 sec.	18.5	—
7	"	3 min. 40 sec.	27.0	—
8	Touched with chloroform	8 min. +	7.0	88
9	"	12 min. +	9½	89
10	Soaked in chloroform	20 min. +	8	81
11	In vapour 5 min.	1 hr. 9 min. +	11	116
12	" 10 min.	17 min. +	—	—
13	" 30 min.	15 min. +	—	—
14	" 30 min.	10 min. +	—	—

can be ascribed to the fact that it consisted primarily of the apical portion in which the air spaces are not well developed (cf. p. 514) and where diffusion would be expected to be slow. It is evident, however, that if these methods seal the lenticels there still appears to be some diffusion through the cork, so that the suggestion made by Brenner (1902), that the cork is of a special kind and pervious, may be partially correct. This is a problem that requires further and more detailed experimentation because the information above is not adequate for a definite conclusion. If we consider the untreated pneumatophores, with the exception of no. 4 it will be seen that there is no significant relationship between length and rate of gaseous interchange, but there does appear to be a relationship between the rate and the number of lenticels. Even here, however, more extensive data would be desirable before regarding this as a definite conclusion.

Experiments were also carried out upon the rate of gaseous diffusion (carbon dioxide being the gas) along both pneumatophores and horizontal roots, the apparatus (text-fig. 162) employed being similar to that used by Troll & Dragendorff (1931). There was a large diffusion chamber with one end tapered out, and into the chamber passed a straight tube sufficiently wide to take a pneumatophore, whilst it also served as the connecting tube between the diffusion and gas chambers. The pneumatophore was cut in the field and brought back in a vasculum and the experiment was performed in less than 1 hr. from the time of cutting. The root was fitted into the connecting tube so that the portion extending into the diffusion chamber was normally from 9 to 12 cm. long. The joints were sealed with paraffin wax and the connecting tube was fitted into the diffusion chamber and this joint also sealed. Next the gas chamber was inverted over the outlet tube of a cylinder containing 10% carbon dioxide and 90% oxygen, except in the last experiment, when the proportions were 25% carbon dioxide to 75% oxygen. The composition of the gas in the cylinders was predetermined on the results obtained by Troll & Dragendorff, because it was found to be more practicable to take out the cylinders from England with the gases already mixed. The results obtained therefore only apply to these special conditions and are not necessarily obtained in nature. The composition of the gas should, in fact, have closely approached that of the atmosphere. After the gas had been running in for some time the flow was stopped and the chamber quickly fitted and sealed on to the connecting tube containing the pneumatophore. Finally, the diffusion chamber was filled with CO<sub>2</sub>-free water and the apparatus left for 2-6 hr. At the end of the experimental period the water in the diffusion chamber was emptied into a beaker containing 10 c.c. of standard baryta, and the excess baryta was

then back titrated with standard HCl. Troll & Dragendorff (1931) adopted much the same technique and assumed that the concentration of carbon dioxide in the gas chamber was actually the same as that put in. In view of the difficulty of filling the gas chamber it seemed not improbable that the concentration was lower, and so in some experiments samples of gas were removed by waving a gas holder vigorously in the gas chamber at the end of the experimental period and analysing the sample thus obtained. This probably results in a value that is lower than is actually the case because the method of gas collection is undoubtedly primitive. It would appear, however, that the actual concentration of carbon dioxide at the beginning of most of the experiments was between 4 and 7%. To obtain uniformity the results (Table VII) have all been calculated

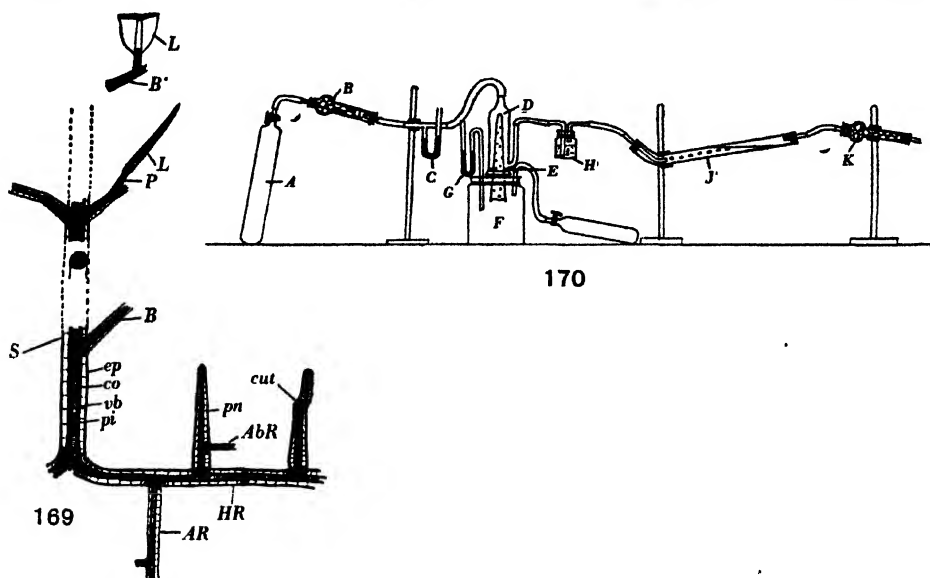
TABLE VII

Exp. no.	Organ	No. of lenticels	Length in diffusion chamber cm.	Total length	% CO <sub>2</sub> used from gas cylinder	Final %CO <sub>2</sub>	g. CO <sub>2</sub> diffused	Rate per cm. per 6 hr.
1	PN	103	12.6	30.6	10	—	0.017	0.00057
2	PN	77	11.0	26.5	10	2.16	0.007	0.00026
3	PN	86	9.2	23.4	10	—	0.092	0.0039
4	PN	79	10.7	27.2	10	—	0.016	0.00058
5	PN	81	10.0	29.0	10	4.16	0.017	0.00058
6	HR	—	—	30.0	10	—	0.016	0.00053
7	HR	—	12.3	30.3	10	4.11	0.018	0.00059
8	HR	—	10.5	—	10	7.76	0.019	—
9	HR and PN	—	17 + 27.5	58.2	25	—	0.064	0.0011

on the basis of a 6 hr. experimental period. With the exception of nos. 2, 3 and 9 the results are remarkably uniform, and one may conclude that under the experimental conditions there is no great difference in the rate of gaseous diffusion in the pneumatophores and horizontal roots. This has some significance when we come to study the anatomy in relation to diffusion. The extremely low percentage of carbon dioxide found in the gas chamber at the termination of Exp. 2 suggests that the initial concentration may not have been as high as in the other experiments or that the seal was faulty. That concentration has some effect upon the rate of diffusion is seen in the last experiment, where 25% carbon dioxide was used in the gas chamber and the rate is consequently nearly doubled. A final analysis was not undertaken in Exp. 3, so that no explanation can be offered to account for the result. The comparable rate of flow in the two types of root is of interest because, unless the cork layer is permeable, the amount of gas diffusing out from the cut end of the horizontal root is about the same as that which diffuses out through the lenticels of a pneumatophore of more or less comparable length.

We may now consider the anatomy of *Avicennia nitida* in relation to gaseous diffusion. It is evident that the large cortical air spaces offer an easy channel for longitudinal gas flow in all organs except near growing apices. If the apex of a pneumatophore is cut off and air is blown down it whilst under-water bubbles only emerge from lenticels and none come from adjacent pneumatophores. If the main stem of a young plant is cut across about 6 in. above the soil surface and air is pumped into the cut surface, bubbles only emerge from the nearest lenticels and none comes from the pneumatophores of the plant. Repeated experiments of this type confirmed the view that ready diffusion of gases is restricted to relatively short lengths of the different organs. This, however, does not mean that the air spaces of the plant are not in complete communication because it is evident that they are, but there are certain tissues, e.g. the closing layer, in the cortex which prevent a ready diffusion of gases. It would seem that when gaseous diffusion

takes place down a pneumatophore and into a horizontal root the flow of gas is restricted to a relatively short distance of the latter, and this perhaps explains the abundance of the pneumatophores. Each pneumatophore is regarded as responsible for the small length of horizontal root associated with it and also with an anchoring root if one arises in the immediate neighbourhood. The small air spaces in the pith of the various organs will not permit of a ready flow of gas down this tissue. Text-figs. 163–165 illustrate the resistances to gas flow in the tissues of a pneumatophore, an absorbing root and a horizontal root. It will be remembered that in describing the actual sections (text-figs. 153–156) it was noted that at the base of both absorbing root and pneumatophore there was a narrow zone of closely packed cells, the closing layer, which must offer a considerable resistance to gaseous diffusion. Unfortunately, no data are available for rate of gas flow from a pneumatophore to a horizontal root, nor are any given for *Sonneratia*



TEXT-FIG. 169. Resistances to gas flow in a mature plant of *Aricennia nitida*. The degree of resistance is indicated by the density of shading. AbR=absorbing root, AR=anchoring root, B=branch, co=cortex, cut=cut end, ep=epidermis, HR=horizontal root, L=leaf, P=petiole, pi=pith, vb=vascular strand. 170. Laboratory apparatus for measurement of respiration.

by Troll & Dragendorff (1931). It will be important in a future investigation to determine the rate of interchange across the closing layer. There is a similar closing layer at the point of origin of an anchoring root with a consequent resistance to diffusion. Apart from these normal resistances there is that associated with wounding when a new apex begins to grow out because again one finds a closing layer, although it is usually not so compact as in the other cases (text-fig. 166). Such 'wound' resistances, however, are not uncommon in both pneumatophores and horizontal roots so that they offer a further hindrance to gaseous interchange.

The anatomical investigation showed that whilst longitudinal diffusion may be relatively easy the same is not true of circular diffusion (cf. p. 507). A study of the lenticels also indicates that the cork cambium probably does not facilitate the entrance of gases, and indeed one has to blow hard in order to expel gas from a pneumatophore.

It is also worth while to consider gaseous movements in other parts of the plant. Throughout the stem lenticels may be found except in perhaps the apical three internodes. Wherever a leaf or a branch arises the cortical air spaces decrease and interchange

will not be easy. In the leaf diffusion is difficult along the petiole and only becomes free in the spongy mesophyll, whilst interchange with the atmosphere takes place not only through the stomata but also through the lenticel hydathodes. In the stem the principal path of diffusion is the cortex, although the air spaces here are not so large as in the cortex of the roots. In the root, in spite of secondary thickening, there may be some interchange between pith and cortex through the medullary rays because the endodermis is not highly developed. In the stem, however, as soon as secondary stellar rings begin to form the limiting band of fibres will effectively prevent any communication between pith and cortex. At the origin of the branches there is not a complete block to longitudinal flow as these organs arise in pairs opposite each other so that there will be a channel between the pairs. An attempt has been made in text-fig. 169 to illustrate the differences in resistance to gaseous flow throughout a well-developed plant of *A. nitida*, and it will be seen that, so far as gaseous diffusion is concerned, the plant is really divided up into units which might almost be regarded as self-contained. If the present investigation does not provide a complete picture it does at least indicate that the aerating function of these roots is a problem worthy of further study. One point, however, is of interest, and that is the relatively low concentrations of carbon dioxide in the horizontal roots. One might have supposed that the percentage of carbon dioxide would have been high because of the difficulty of diffusion into the pneumatophores, but it is possible that the frequency of the pneumatophores compensates for the difficulty of diffusion. From this point of view it would be well worth while studying the frequency with which pneumatophores occur in relation to soil type and root morphology.

**B. Absorbing roots.** The morphological study indicated that one of the important functions of the pneumatophores might be the production and maintenance of the absorbing rootlets in the better aerated and less waterlogged soil near the surface. Field observations showed that as the soil surface increased in height so new absorbing rootlets were produced higher up on the pneumatophores whilst those lower down died. This process was particularly obvious in the sand-spit at Hunts Bay where accretion from wave action is rapid, and as a result the successive absorbing roots were widely spaced (text-fig. 149). In the peat areas where there was little or no accretion, the absorbing roots were found low down on the pneumatophore and closely packed together (text-fig. 157), although the occasional development of absorbing roots high above the soil surface suggests that there may be an hereditary factor which can be modified by the environment. In the mud areas, where the rate of accretion is intermediate, the distribution of absorbing roots was also intermediate in character. On the fringes of the cays where the horizontal roots are frequently found growing on the soil surface among the coral boulders, the pneumatophores are wholly above the surface and do not bear any absorbing roots: instead these latter grow out from the lower surface of the horizontal roots. There would thus seem to be adequate evidence that one of the important functions, though not the only one, is the production of absorbing roots at a definite level in relation to the soil surface.

**C. Respiration.** In their investigation of the pneumatophores of *Sonneratia alba* Troll & Dragendorff (1931) attempted to measure the total and partial respiration of these organs *in situ*, but they found that this was impracticable. They were therefore reduced to measuring the respiration under laboratory conditions, but as their apparatus was somewhat cumbersome the modification illustrated in text-fig. 170 was employed in my investigations. In the first few experiments a gas cylinder (*A*) was provided containing air free of carbon dioxide for passing through the apparatus; unfortunately, the valve developed a leak and the gas escaped before all the experiments were completed. In the later experiments, therefore, air was drawn through by means of an aspirator which was not present in the earlier experiments. The air was passed first through a soda-lime tube (*B*) which was connected to the gas chamber (*D*) by means of a tube with a mano-

meter (*C*) in order to indicate the gas pressure in the system. The pneumatophore was fixed into the gas chamber and the bottom sealed by the mercury (*E*). The lower part of the pneumatophore penetrated into the gas reservoir (*F*) which was fitted with a manometer (*G*) to indicate maintenance of pressure or leakages; there was also another tube to which a gas cylinder containing a known percentage of carbon dioxide could be attached. After leaving the gas chamber the air was passed through a wash bottle (*H*) containing strong sulphuric acid and then through a Pettenkoffer tube (*J*) filled with standard baryta solution, the open end of the tube being closed with a soda-lime tube (*K*). In the later experiments where air had to be drawn through, a blank experiment was performed first in order to ensure that all the carbon dioxide was removed by the initial soda-lime tube.

Four sets of investigations were carried out in the laboratory, each set consisting of three separate experiments with the same pneumatophore. These pneumatophores were freshly cut and the experiments began within thirty minutes of cutting. In the first experiment the gas reservoir contained a layer of strong lime water in order to absorb any carbon dioxide present, so that the carbon dioxide absorbed in the Pettenkoffer must have come from the respiratory activities of the pneumatophore itself and must have diffused through the lenticels. This represents the partial respiration *P*.<sup>1</sup> In the first set a pneumatophore with absorbing roots attached was used and the initial experiment ran for 1½ hr. At the end of that time the Pettenkoffer tube was emptied out and the baryta titrated with standard acid, and as a blank determination of the baryta solution had been made beforehand the difference represented the actual carbon dioxide evolved. The lime water was then emptied out of the gas reservoir, the latter was cleansed and air containing 10% carbon dioxide was run in and the apparatus refitted but with the 10% carbon dioxide cylinder attached to the gas reservoir. The experiment ran for ¼ hr., after which it was repeated with 25% carbon dioxide in the gas reservoir. The second two experiments were regarded as providing a total respiration (*R*), the gas reservoir representing a source equivalent to that given by the horizontal roots. It must be realized that the concentrations of carbon dioxide were much higher than had been found by analysis in the horizontal roots, but this could not be remedied as the preparation of the cylinders in England was based upon Troll & Dragendorff's results.

In set 2 a pneumatophore with the absorbing roots was again used and the first experiment with air free of carbon dioxide ran for 1½ hr. The second and third experiments with 10 and 25% carbon dioxide respectively ran for ¼ hr. each. In both sets 3 and 4 a pneumatophore with a portion of the horizontal root attached was employed, the experiments with air free of carbon dioxide running for 1½ hr. and those with 25% carbon dioxide for ¼ hr. The results of all these experiments are expressed in Table VIII on a 2 hr. basis.

These results show that in all cases there is a significant partial respiration and it may form up to 70% of *R*. In series 1 and 2 *P* formed more than 50% except in 2c. In series 3 and 4, where there was a portion of horizontal root attached, *P* was less than 50% *R*. It should be stated that when 10 or 25% carbon dioxide was used in the reservoir the pressure was maintained at that of the outside atmosphere so that gas was not forced through the pneumatophore. In series 1 and 2 there will be some respiratory carbon dioxide from the absorbing roots. In series 3 and 4 there will be similar carbon dioxide from the small portion of horizontal root.

Finally, an attempt was made to ascertain whether there was any correlation between respiratory activity and distance from the parent stem. These experiments, unfortunately, were not completed owing to the outbreak of war.

The results were not conclusive, and it was somewhat surprising to find a lower

<sup>1</sup> These values may be low because a small amount of carbon dioxide probably diffused out through the cut end. This could not be sealed because of the subsequent experiments.



TABLE VIII

Exp. no.		Gas reservoir	Respiration	g. CO <sub>2</sub> respired in 2 hr.
1a	Pneumatophore + absorbing roots	0 % CO <sub>2</sub>	P.	0.07
1b	"	10 % CO <sub>2</sub>	R.	0.12
1c	"	25 % CO <sub>2</sub>	R.	0.10
2a	Pneumatophore + absorbing roots	0 % CO <sub>2</sub>	P.	0.038
2b	"	10 % CO <sub>2</sub>	R.	0.06
2c	"	25 % CO <sub>2</sub>	R.	0.13
3a	Pneumatophore + horizontal root	0 % CO <sub>2</sub>	P.	0.067
3b	"	25 % CO <sub>2</sub>	R.	0.54
4a	Pneumatophore + horizontal root	0 % CO <sub>2</sub>	P.	0.03
4b	"	25 % CO <sub>2</sub>	R.	0.18

25 % CO<sub>2</sub> had to be used for series 3 and 4 as the supply of 10 % CO<sub>2</sub> had been exhausted.

total respiration nearer the main stem than farther away. This may be due to the fact that towards the periphery of the root system both horizontal roots and pneumatophores are much younger and therefore respire more vigorously. In an experiment where the base was compressed the respiratory activity was stimulated to a high degree.

We may conclude therefore from these observations and field experiments that the pneumatophores of *Avicennia nitida* have at least three functions. First, they provide a means of gaseous interchange between the atmosphere and the subterranean roots, although this is probably more local than might be expected. Secondly, they normally bear and maintain the absorbing roots at what one must regard as the most advantageous level in the soil. Thirdly, they are normal respiratory organs. The emphasis on respiration must be made because most earlier workers have neglected it wholly when considering the aerating function, and the experiments described above suggest that P forms a high proportion of R. An important feature pointed out by Karsten (1891), which merits further study, is the restriction of pneumatophores to relatively quick-growing mangroves and their absence from those that are slow growing. Whether this observation can be correlated with the development of cork in the roots the present author is not in a position to say.

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Fig. 1. *Avicennia* and pneumatophores near Plumb Point. (H. H. T.)



Fig. 2. Young plant of *Avicennia nitida* (V J C) Note radiating rows of pneumatophores. This also shows set up of respiration apparatus.



Fig. 3. Pneumatophores of *Avicennia nitida*. (K R. S.)



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## EXPLANATION OF PLATE 21.

- Fig. 1. *Avicennia* and pneumatophores near Plumb Point. (H.H.T.)  
Fig. 2. Young plant of *Avicennia nitida*. (V.J.C.) Note radiating rows of pneumatophores. This also shows set up of respiration apparatus.  
Fig. 3. Pneumatophores of *Avicennia nitida*. (K.R.S.)



## THE HOOKER LECTURE

*Pachytheca* and some anomalous early plants (*Prototaxites*, *Nematothallus*, *Parka*, *Foerstia*, *Orvillea* n.g.). By WILLIAM H. LANG

[With Plates 22-25]

[Delivered 27 April 1944]

There is, as there should be, a connexion between the subject of this lecture and one small facet of the great and many-sided botanical work of Sir Joseph Hooker. This lies in the fact that he saw and in some cases studied a few pre-Carboniferous plants. But in comparison with the broad sweep of his contributions to systematic botany, geographical botany and evolution, even the whole of his work on fossil botany is a short and relatively minor episode in his scientific career. He was already an experienced traveller, collector and systematist when, for considerably under two years, he held an appointment as Botanist to the Geological Survey. He worked intensely and with interest on Carboniferous plants and published two important papers and a general essay on the flora of that period. That was in 1846-7. Then came the Indian journeys. For a few years after his return in 1850 there was a much slighter connexion with the Survey, resulting in a small number of short papers or notes, including some on Downtonian and Old Red Sandstone plants.

The condition both of general botany and of palaeobotany at this time should be borne in mind. For instance, the approach to both was mainly systematic, and knowledge of the life histories of existing plants was hardly in its first stages. The study of Carboniferous plants was only beginning to be freed from attempts to identify them with existing forms; and there were only the first cases of supplementing information from external form by careful investigation of structure. In both these lines of advance Hooker's work holds a place.

If the study of fossil plants back to the Carboniferous was still in its later pioneer stage in the period from 1845 to 1855 within which Hooker's work on the subject falls, knowledge of pre-Carboniferous plants was only beginning. Indeed, at this time and for long afterwards, such early remains were a concern rather of geologists than of botanists. So far as we have evidence, Hooker was acquainted, usually barely more, with some four or five plant remains from pre-Carboniferous rocks. These include the fossils we now know as *Pachytheca*, *Prototaxites*, the Corduroy Plant, *Hostimella racemosa* and, perhaps, the Downtonian fossil of uncertain nature *Actinophyllum*.

### *Pachytheca*

The fossil plant that longest engaged the active attention of Hooker was a small spherical body half a centimetre or less in diameter, which is met with, often in numbers, in some early palaeozoic rocks in Britain. Murchison knew of petrified specimens and, under the name *Bufo-nites*, regarded them as parts of the palate of fishes; other early references are to black spots in the rock.

The botanical history of the fossil begins in 1852 when Strickland, studying the organic contents of the Bone-bed and overlying Downton Sandstone noted, along with obscure carbonaceous remains, seed-like bodies. These are further referred to in a second paper in 1853, and printed immediately after this is a note on the seed-like bodies by Hooker. He did not entertain the idea of their being seeds but regarded them as lycopodiaceous sporangia. The grounds for this were the central cavity and the wall, apparently composed of radially extended cells. It will be remembered that one of Hooker's investigations had been on the structure of *Lepidostrobus* including that of the sporangium. In the text of Strickland's paper is a figure showing clearly the features which he and Hooker had before them (*Quart. J. Geol. Soc.* ix).

There were no additions to our knowledge of the fossil in the next twenty years, but in 1861 Salter, when recording its occurrence in the Downton Sandstone near Malvern, stated that Hooker now gives it the name *Pachytheca*.

In 1875 Hooker received some petrified specimens of *Pachytheca* from the Wenlock Limestone near Malvern. Dr Grindod, who had collected them, was convinced of their lycopod nature but proposed to have sections made of some of them. Hooker at once had this done and the sections, as he has told us, 'at once revealed to me the Algal nature'. At this time he evidently studied the fossil anew and made careful drawings, but nothing was published. The sections were shown to a number of botanists, who agreed as to the algal nature of the fossil but differed among themselves as to the precise interpretation of the appearances. The sections, or some of them, appear to have passed into the keeping of Thiselton-Dyer and were studied by him.

In 1881 Hicks found *Pachytheca*, along with fragments of *Prototaxites*, in the Pen-y-glog Grit of Wenlock age near Corwen. In the papers (*Quart. J. Geol. Soc.* xxxvii and xxxviii) dealing with these discoveries the most various opinions were expressed as to the nature of *Pachytheca*—a lycopod sporangium; a seed (*Aetheotesta*) possibly belonging to *Prototaxites*; a reproductive part of *Prototaxites* (*Nematophycus*) regarded as a marine alga; possibly not a plant but an animal. The chief interest of these discussions for us is, however, that Dyer sent for exhibition Hooker's Malvern specimens. These were accompanied by a letter which is the first published statement that *Pachytheca* is an alga; Dyer also states that there is continuity between the filaments filling the central cavity and those radiating through the cortex.

The first publication of some of Hooker's drawings showing the algal structure came about almost by accident in 1884. His friend La Touche was preparing a *Handbook to the Geology of Shropshire*. On Plate XVI two specimens were figured of natural size, showing no details and labelled on the plate '*Lycopodium* spores'. Evidently Hooker volunteered better figures, and on the last plate is a selection of his drawings made from the Malvern specimens of *Pachytheca* and a descriptive legend. It is worth while quoting this in full:

'Confervoid alga forming a hollow sphere,  $\frac{1}{3}$  to  $\frac{1}{5}$  of an inch or less in diameter; cortical portion thick, formed of densely packed, radiating, jointed filaments,  $\frac{1}{1000}$  of an inch in diameter, terminating towards the central cavity in irregularly disposed oblong cells, of much greater diameter than the filaments. Central cavity variable in size, greater or less in diameter than the thickness of the cortex, loosely traversed by jointed unbranched filaments about  $\frac{1}{1000}$  of an inch in diameter, resembling those of an *Oedogonium*.'

The full set of Hooker's drawings, probably made shortly after 1875 from specimens that were later lost, was published in the *Annals of Botany* for 1889 (vol. III). They show the septate algal filaments both in the medulla and the cortex. In the cortex of one specimen they stand close together as they radiate outwards. In that of a second specimen 'the filaments are separately embedded in the mineral matrix'. It is explicitly stated that no organic connexion between the filaments of the central region and those of the cortex had been observed by Hooker. He comments on the importance of the statement that this occurred, if the fact is confirmed. It seems possible that Dyer's observation was made on a different and better specimen, for in the sections figured by Hooker there is the appearance of a zone, two or three layers deep of 'parenchymatous cells', wider than the filaments and forming the innermost part of the cortex. There is every reason to regard this appearance as an artefact due to the petrification. Its presence in these specimens, on which Hooker relied, explains his persistent doubts as to the filaments of medulla and cortex belonging to the one algal organism. Hooker's paper is in main part concerned with giving the history of the study of *Pachytheca*. But it also contains interesting remarks on the indications that the organism must have had considerable rigidity and resistance to decay, and on the absence of any point of attachment on the surface of the specimens. Various possible comparisons with Blue-Green Algae and Green Algae are mentioned.

Though the paper concludes by deferring any certain conclusions as to the real nature and affinities of *Pachytheca*, it seems clear that the general algal nature is maintained.

Hooker's interest in the study of this fossil had led him in 1887 to entrust the two remaining sections of the Malvern specimens to Barber, an able young laboratory botanist as systematists might have described him, for reinvestigation. The results of this appeared in Barber's first paper on *Pachytheca* printed immediately after Hooker's paper in the *Annals of Botany* for 1889. In this paper, illustrated by very beautiful and accurate drawings, the structure of the medullary and cortical filaments and their algal cells is shown with great clearness. Although one gets a strong general impression that the filaments are identical and must be continuous, Barber could not reach certainty as to this. He was, in fact, involved in difficulties due to appearances in the same inner region of the cortex which, otherwise petrified, had misled Hooker. This was Barber's 'zone of oval bodies', and he also was troubled by their apparently cellular nature.

In a second paper (*Ann. Bot.* v, 1891) Barber studied a number of sections of *Pachytheca* prepared by Storrie from petrified specimens collected in the Rhymney Grit of Tymawr Quarry. These were mineralized in various ways, and allowances had to be made for the diverse appearances thus produced. The algal filaments were less well preserved than in the Malvern specimens but could be traced by their persistent transverse walls. The two important results of this study were: (i) that the oval bodies were explained as wider portions of the cortical, interfilamentous material, and (ii) that continuity between the medullary filaments and those passing out radially between the 'oval bodies' and on through the cortex was definitely established. A note by Dyer in the same volume emphasizes the fact that his earlier statement is thus confirmed.

The whole course of botanical work on *Pachytheca* from 1858 to 1891 will be seen to have been directly or indirectly due to Hooker. In addition to his own observations and opinions the sections examined by Dyer came from him, and it was his wise decision to pass on the investigation of the fossil to Barber. The first period in 1853 is concerned with a systematic approach to Downtonian specimens and led to the view, which proved erroneous, that *Pachytheca* was a lycopodiaceous sporangium. The second period, which began in 1875, was determined by the discovery of some well-preserved Silurian specimens. The approach was now by way of a study of the microscopical structure of the fossil and at once led Hooker to correct his earlier opinion of its nature and to recognize that it was an alga. The peculiar mineralization of petrified specimens in the inner region of the cortex prevented for a long time the correct description of the algal structure as a continuous system of septate filaments in the medulla and extending radially through the cortex. This view, earlier expressed by Dyer, was established by the later work of Barber.

By 1891 the main facts regarding this small globular fossil plant seemed to be clear and the difficulties removed. It is recognized that it is an alga, normally unattached and without any indication of a place of attachment; that it probably rolled about on the sea (or lake) bottom; and that specimens of various sizes occur together. From the way in which its shape is preserved its firmness and rigidity can be deduced. It seems clear, though this is not explicitly emphasized, that this rigidity must have been due to the firm interfilamentous material of the cortex. The algal filaments have been shown to be septate and to be continuous from medulla to cortex. Its systematic position within the Algae is uncertain. The most probable comparisons are tentatively made with *Cladophora*, and especially with colonies of Blue-Green Algae; other suggestions are less satisfactory.

In 1895, however, a single peculiar and still obscure specimen, which had been collected by Storrie from the Rhymney Grit, was described by George Murray (*Phycological Memoirs*, Part III). It consisted of a small *Pachytheca* showing the usual structure and without any mark of having been attached. But it had been found seated in a cup-like structure, in which, however, it is stated to have been loose. This cup, which extended about half-way up the *Pachytheca*, had no preserved structure in common with the latter;



it exhibited a number of other features including a central region in the concavity and a roughening of the lower portion of its outer surface due to projecting spine-like bodies. Murray remarks that it only makes the nature of *Pachytheca* more obscure.

We have Hooker's reaction to the information in a letter he wrote to La Touche on the day he saw Murray's paper. He appears to have naturally taken the specimen at its face value and regarded it as upsetting the conclusions from his own and Barber's investigations which were summarized above. He concludes his letter by quoting 'ex uno disce omnes'.

I am not, however, going to do this, and must indicate my position here. We must, of course, keep this specimen in mind and look out for confirmatory and more intelligible examples of a similar kind. So far none has been found; the specimen is unique. That would in no way lessen its overriding value if the facts regarding it were clear and convincing. But the unique specimen is an enigmatic conundrum. It is not morphologically consistent or self-explanatory, as is well seen from Murray's reconstruction; in this there is no intelligible connexion between the *Pachytheca* and the cup, whatever the latter may be. So, keeping it in the background, though not forgotten, I am inclined to expect that when, or if, it is explained, it may be explained away. At any rate it does not give any clear alternative view of what can be observed in the large number of examples of *Pachytheca* that have been examined. We must continue to investigate such specimens for what they demonstrate, in favourable cases.

There was no further work on *Pachytheca* for nearly thirty years. Since 1923, however, there have been a number of additions to our knowledge which amplify but are all consistent with the results of the investigations of Hooker and Barber. They need not be dealt with in detail or in historical order but may be briefly considered as they concern geographical distribution, stratigraphical range in Britain, and morphology.

*Geographical distribution.* *Pachytheca*, originally discovered in Britain, has been found most abundantly there. There are now, however, a small number of clear records of its occurrence in other countries which show that it was of world-wide distribution. It is recorded from Canada in beds that are now regarded as Middle Devonian. In Australia it is found in beds of Ludlovian age. It has been found in a number of localities in the Lower Devonian of Belgium. Lastly, there is a record of it as an alga from Germany; these specimens were regarded by their discoverer as the 'facetted eyes of Crustaceans', one of the last of various attempts to replace *Pachytheca* in the animal kingdom.

*Stratigraphical range of Pachytheca in Britain.* The special interest that attaches to the stratigraphical range of *Pachytheca* in British rocks is because of its bearing on the probable habitat of the alga. In England and Wales it is known from the Silurian (Wenlockian, Ludlovian), at fossiliferous levels throughout the Downtonian, from the Dittonian and from the Senni Beds. In Scotland it is recorded, but not critically investigated, from the Downtonian at Lesmahagow; it is met with in the Carmyllie and Cairncannan Beds and in Glencoe at a correspondingly low horizon of the Lower Old Red Sandstone, and also at the higher horizon represented by the Strathmore beds in Perthshire. One specimen has also been found in the Rhynie outlier, regarded as of Middle Old Red Sandstone age.

There seems to be established geological opinion that the rocks of all the higher horizons in this list are purely continental deposits, so that in the Middle Old Red Sandstone, the Strathmore and the Senni Beds, and the Carmyllie Beds, corresponding to the Dittonian, *Pachytheca* can only have lived as a fresh-water alga. This may apply to the upper portion of the Downtonian also. In the lower beds of the Downtonian in England and Wales a few marine invertebrates occur with the plant remains and the Silurian Beds are definitely marine, though those with *Pachytheca* seem to have been near the shore.

When *Pachytheca* occurs in these brackish or salt-water deposits it may have been carried down from the neighbouring land or it may, of course, have been able to live and multiply in salt water as well as in fresh. The possibility of *Pachytheca* and associated

plant remains in purely marine strata having come from the land has been entertained<sup>2</sup> from the geological side.

It would lead too far and is unnecessary to consider the interpretations now adopted by geologists of the sequence of strata from the Silurian to the top of the Old Red Sandstone both in England and Wales and Scotland. It is sufficient to say that in both regions a progressive deltaic accumulation is recognized, the passage to purely continental conditions being somewhere in the upper part of the Downtonian or even earlier in some regions.

*Morphology.* The great majority of the British specimens in the various horizons mentioned above, and all those so far described from other regions present the appearance of medulla and cortex adequate for their recognition as *Pachythea* but add nothing to our knowledge. Advances in understanding must depend, as they have done in earlier work, on critical study of good instructive specimens.

Silicified specimens collected in 1923 in a bed of black shale on the side of Stob Dearg in Glencoe have been described under the name *P. fasciculata* (for figures see *Trans. Roy. Soc. Edinb.*, LIII, no. 29), and have added a number of significant facts. They show the general characters of the plant, the medulla surrounded by a cortex with a thin clear outer zone. The remarkable difference, however, is that each radiating tube in the cortex encloses a number of the algal filaments, which in this very distinct species are much more slender than the single filaments in the Silurian specimens from Malvern and Rhymney to which the name *P. Hookeri* was given. The latter had filaments 12–20 $\mu$  in diameter, while the filaments of *P. fasciculata* are only 2–5 $\mu$  thick. The septate filaments form a crowded mass in the medulla and can be seen at favourable places bending out into the cortical tubes. The latter are sometimes closely placed but are often widely separated by the intertubular material in the innermost zone of the cortex giving the appearance of Barber's 'zoné of oval bodies'. As the tubes branch they become more closely fitted together farther out. Not one, but a number of algal filaments have been traced in each of these tubes. They are to be seen in longitudinal view, but their number is best demonstrated when compression of the cortex before petrification had bent the tubes, so that they are seen cut across. The tube then shows a distinct wall and within it some seven or more algal filaments with intervals between them. The tubes appear to end just before the clear outer zone of the cortex is reached, but the fine filaments are traceable across this in bundles, each emerging from one tube. It will be evident that the whole structure of the algal colony is confirmatory of what was ascertained from the best Silurian specimens, all the more because of essential differences. The nature of the clear outer zone of the cortex becomes more intelligible. We are forced in *P. fasciculata* to distinguish cortical tubes as distinct from the walls of the algal filaments; when the latter are solitary and wider it is difficult or impossible to distinguish a cortical tube outside the cell wall. The condition in *P. fasciculata* supports the cases in the other type where there is a suggestion of a tube being distinguishable.

As has been known since Strickland and Hooker's work of 1853, *Pachythea* is very abundant in the Downton Sandstone and the Ludlow Bone Bed, especially just above the latter. Most specimens are carbonized, but some are petrified. It is thus possible to consider and compare the information given by two types of fossil based on the same plant (for figures see *Philos. Trans. B*, CXXXVII, Plate 14).

When sections were ground of a considerable number of petrified specimens from the Saltwells' outlier most proved to be poor and uninformative but a few were fairly good. For example, a specimen with the medullary tissue gone and replaced by mineral material had a well-preserved cortex. The septate algal filaments, 10–12.5 $\mu$  wide, ran singly through this, unbranched or, at places, clearly branched, and separated fairly widely by interfamilamentous material. The whole structure is like some of the Malvern specimens and, as in them, there are contracted remains of cell contents that seem to just fail to give the much desired information as to the structure of the protoplast. This is the condition in

the least altered or best-preserved parts of the cortex, but in much of its extent mineralization of the interfilamentous material has obscured the true structure.

The very numerous carbonized specimens were long regarded as giving little more information than the gross distinction of medulla and cortex. But it is possible to dissolve away the rock and extract such examples coherent and intact. They can then be embedded in paraffin and cut on a rocking microtome. The serial sections afford an approach to the consideration of the structure that is usefully different from that given by ground sections of petrified specimens from the same horizon. The tangential sections of the cortex cut the tube-like passages transversely. The more or less abundant interfilamentous material is black and homogeneous; within each of the tubular passages the contracted remains of a single algal filament can be seen. As the series of sections continues inwards the interstitial material ceases to form tubular passages and separates into black masses, which have been seen in petrified specimens as the 'oval bodies'; the algal filaments lie between and around these. Still deeper the section passes through the medulla with the algal filaments cut into short lengths and no black interfilamentous material. It is especially as regards the distribution of the latter in the colony as a whole that the study of such a microtome series is valuable.

We are getting very near to having a conception of the structure of *Pachytheca* in the solid that enables us to look at a specimen much as we should at an existing plant. I may illustrate this by an example. On a rock surface from the Downton Sandstone were numerous split *Pachytheca* spheres of various sizes, some clear and distinct, others merely circular, black spots. Among them was a large intact specimen projecting from the rock as a black shiny hemisphere. It looked as if it might be petrified, but when a needle was pressed against it, proved to be soft; and the coherent cortex split off from the upper side in two or three pieces. The medullary cavity was full of soft material, a portion of which was easily removed with the wetted point of a needle. When put into a drop of water on a slide and further broken up it was found to consist entirely of medullary filaments without any interstitial substance; portions of the filaments showed branching. The black cortical zone had radial striation due to the tubular canals each of which doubtless contained a contracted algal filament, and, next the medulla, the wider masses of interfilamentous material ('oval bodies'). The latter were also clearly visible on the inner faces of the pieces of cortex under reflected light, and the free medullary algal filaments could be seen bending out between the black masses.

The general construction of *Pachytheca* that holds for the majority of numerous specimens is thus easily grasped and understood. It seems legitimate to translate what can be seen in the fossil into the probable appearance of such a colony in the living condition by picturing the system of algal filaments as green or blue-green and the interfilamentous material of the cortex as firm translucent mucilage.

A few points, all of which require further inquiry, may be briefly touched upon. Thus two or three specimens, hardly more so far, have suggested or demonstrated an interruption in the usually complete cortical covering of the medulla. Such specimens have an evident bearing on the possibility that in some cases *Pachytheca* may have been attached; they may, on the other hand, merely express a developmental defect. There is nothing to suggest that they have any relation to the specimen in a cup.

The diversity in detail as regards such features as the proportions of medulla and cortex and the crowding together or separation by interfilamentous substance of the cortical filaments has been met with in sets of specimens from a number of localities; clearly these are individual and not specific differences. As regards the distinction of species the only well-marked contrast is that between the sets of specimens from various localities and horizons in which the filaments run singly through the cortex and the form from Glenoe with a number of fine filaments in each cortical tube. The latter is named *P. fasciculata*. A typical example of the former type is afforded by the Wenlockian specimens from Malvern to which the name *P. Hookeri* has been applied. Some time ago the attempt was

made to draw further specific distinctions on the basis of the diameters of the algal filaments, but, with the multiplication of measured widths with no other differences, it is useless to pursue this, for the present at least. The specimens to which Hooker gave the name *P. sphaerica* were from the Downton Sandstone, but specimens with at least two widths of filaments are known from this horizon and there are, of course, no type specimens.

A very considerable range in size can be noted wherever numerous specimens, that there is little doubt were of the same species, occur crowded together, as, just above the Bone-Bed, or in thin flood beds at other horizons. The range is from 5 or 6 mm., through 4, 3, 2, to 1 mm., and even less. There is not enough information as to the structure of the smallest specimens, but fairly small ones have the distinction of cortex and medulla.

Our considerable knowledge of the construction of the mature individuals or colonies of *Pachytheca*, taken together with this range in size, raises the interesting but difficult question of how such bodies developed. In thinking of this the contrast between the mass of free filaments of the medulla and the radially placed filaments of the cortex, often embedded in an apparently rigid mass of interfilamentous 'mucilage', has to be kept in mind. It is difficult to picture how a colony 2 mm. in diameter, with complete cortex around its medulla, could grow into a specimen 5 mm. in diameter. It is well worth thinking about the problem and searching for any specimens that may provide evidence upon it. There is as yet no such information, but *Pachytheca* must have developed. We also know nothing as to its reproduction, either vegetative or by special reproductive cells. As the repeated comparisons with Blue-Green Algae suggest, it may have been purely vegetative.

Lastly, as to the systematic position of *Pachytheca*, we cannot go much beyond the tentative suggestions of Hooker and Barber. We may remind ourselves of the enigmatic specimen in a cup, but it does not help and need not be allowed to hinder. *Pachytheca* was certainly an alga, taking this in a broad sense as including the Blue-Green Algae. But we cannot place it with certainty in any particular subdivision, nor do we know any recent or fossil form that is closely comparable in morphological construction. The alternatives seem to be a fresh-water filamentous Green Alga or one of the Blue-Green Algae. The algal filaments in the Malvern specimens seemed to Barber to be too complex for the latter group. On the other hand, the slender filaments and the presence of a number of them in each cortical tube in the Glencoe species strengthen comparisons with the Blue-Green Algae. Perhaps a specialized colonial form in this group is the most likely direction in which to look. But the question must be left an open one. It is not quite impossible that the discovery of specimens with better preserved cell contents may give the key to this unsolved problem.

In concluding this consideration of *Pachytheca* and as leading on to the second subject of this lecture, I may quote a sentence from one of Hooker's letters written in 1888, probably when preparing the paper for the *Annals of Botany*: '*Pachytheca* gets more and more inscrutable. My impression still is that it is in all probability a type of structure of which there is no existing type—and of such structures there must have been thousands of old.' Shortly after this was written, the removal of difficulties by Barber's work made the structure of the *Pachytheca* sphere much less inscrutable; though it still remains a unique type of alga.

Just as *Pachytheca*, though an isolated type, can be placed in its great systematic group, it can be said generally that almost all fossil plants that are sufficiently known can at least be put into one or other of the great groups of the vegetable kingdom that make up the existing flora. By great groups I do not mean strictly natural phyla but the comprehensive practically convenient groups: Angiosperms; Gymnosperms; Pteridophyta, Bryophyta, Algae and Blue-Green Algae; Fungi and Bacteria. This indeed applies not only to Tertiary, Mesozoic and Carboniferous plants but to almost all the types that have been added to the natural system by the study of early palaeozoic plants. Thus it holds for vascular plants that can be placed in the Pteridophyta, although they may be so

distinct as to require the institution of a separate class, or possibly classes. The simple rootless and leafless forms, such as *Cooksonia*, *Rhynia* and *Zosterophyllum*, are prominent examples, so are somewhat more complex forms like *Psilophyton*, *Thursophyton* and *Asteroxylon*. Other plants, at least from the Upper Devonian, can be placed without hesitation in Gymnosperms. A number of still insufficiently known fossil plants have to be held in suspense as between a position in Pteridophyta or Gymnospermae. The interesting fossil *Sporogonites*, so admirably investigated by Halle, similarly remains in suspense as to whether it will prove to be a bryophyte or a pteridophyte.

There are, however, a few ancient plants which seem difficult or impossible to place in any of the great groups, not from the imperfection of our knowledge (although it is, of course, in every case very imperfect), but because of certain positive, well-ascertained, morphological characters, vegetative or reproductive or both. It is such plants that, for want of a better term, I refer to as anomalous. There are a few vascular plants that may possibly come under this heading, but none of them that are under suspicion are sufficiently known as regards essential features to justify their discussion.

The few anomalous plants that I shall consider here either have been or might be forced into the great group of Algae, but not naturally as one is led to place *Pachytheca* there. They fall into three sets: (1) *Prototaxites* and *Nematophallus*, (2) *Parka*, (3) *Foerstia* and *Orvillea*. The description of the first four of these will be kept as brief as possible, since there is little to add to what can be found in the literature. The last plant, to which the name *Orvillea* is given here, will require fuller description and illustration since most of the facts are new.

*Prototaxites* Daws. (*Nematophycus* Carr, *Nematophyton* Daws. & Penh.)

For figures cf. Seward, *Fossil Plants*, vol. I, fig. 39; and Barber, *Ann. Bot.* vi, Pl. XIX

*Prototaxites* was named and made known by the accounts given by Dawson in 1859 and 1871. The material from Gaspé was great trunks with structure preserved, and smaller pieces and fragments with the same structure. Carbonized fragments had been known earlier from the Downtonian of Britain, and Hooker (1853) refers to some as 'fossil wood' but did not investigate them. Dawson's material suggested the central woody portion of tree trunks, nothing being known of the surface tissues or of the habit and appendages of the plant. He regarded *Prototaxites* as a primaeval gymnosperm. In describing it he missed details of the structure, only noticing the wide, longitudinally running elements. But he sent good material to this country and Carruthers, on studying sections of this, ascertained and accurately figured the essential structural details. He found it consisted of a system of wide, thick-walled tubes running longitudinally, and of a system of narrow thin-walled tubes running in all directions between them. The narrow tubes are massed together in certain regions, which had been regarded as medullary rays. Carruthers's opinion was definite that the plant was a large marine alga. He compared it structurally with Siphonaceae and in size, and in an appearance of 'annual rings', with large Laminariaceae. Two contrasting views had thus emerged, that it was a land- or swamp-living tree and that it was a giant marine alga.

These opposed views persist, in part at least, to the present. The tendency for a long time was to accept the view that *Prototaxites* (or *Nematophycus* as Carruthers renamed it) was an alga. Further, leaving aside the caution in his comparisons, it was treated as structurally, as well as in size, comparable with Laminariales, a view open to serious criticism. Indeed, Church remarks in a footnote in the Thalassiophyta that it is 'nothing in the world like any Laminarian', and treats it among the fungi.

All that can be done here is to look at the unique structure that has led to such divergent opinions, recognizing the systems of wide and narrow tubes; the massing of the latter in medullary spots or rays; and the entry into these regions of wide tubes, which appear to subdivide and may be continuous with narrow tubes.

The question might be left at that, wholly an open one. But it must be remarked that as to a continental or a marine habitat there seems inescapable support for the former. In the stratigraphical sequence in Britain, already considered in relation to *Pachythea*, *Prototaxites* occurs in the Middle Old Red Sandstone, in the upper horizon of the Lower Old Red Sandstone (Senni Beds) in the lower horizon of the same formation (Dittonian, Carmyllie Beds) in the Downtonian and in the Silurian (Ludlovian, Wenlockian). As has been seen, there is geological agreement as to the purely continental condition of all the higher horizons. It is further significant that it is in these that the largest specimens of *Prototaxites* have been met with. In the Downtonian and still more markedly in the various Silurian localities this plant is found in small fragments along with *Pachythea*. The indications are that it may have been carried down into these marine deposits from a neighbouring land.

The geographical range of *Prototaxites* includes Britain, Belgium, Germany, the Sahara, Canada and North America. It was evidently a widely distributed and common plant in Silurian and Lower Devonian times and continued into the Middle and the Upper Devonian.

#### *Nematothallus*

For figures see *Philos. Trans. B*, vol. CCXXVII, Plates 11, 12

Much more recently, and so far only in Britain, another type of fossil plant has been clearly recognized, the general structure of which corresponds with that of *Prototaxites*. It is known only as larger or smaller pieces of thin flattened expansions in the rock, often almost covering the bedding planes but in other cases as isolated specimens. It has been named *Nematothallus*. It was long overlooked, perhaps confused with poor specimens of Eurypterid skin or classed as indeterminable vegetable remains. The first clear comment upon it is a remark by Mr E. Dixon that numerous leaf-like fragments occurred in the Downtonian of Fresh Water East in south Pembrokeshire. The range is now known to be from the Ludlovian, throughout the Downtonian, in the lower and upper fossiliferous horizons of the Lower Old Red Sandstone both in England and Wales and Scotland and, perhaps, in the Middle Old Red Sandstone at Cromarty. The indications of a continental habitat are thus as clear as for *Prototaxites*. In the Silurian it has only been met with in small fragments, but these are structurally certain.

The basis of construction is like that of *Prototaxites*, a system of associated tubes. In the most typical form, there is a system of wide tubes running in all directions and between them a system of narrow tubes. The wide tubes are often black and opaque but are not infrequently preserved so as to be translucent. They then show a rather thin wall with a fine annular thickening that gives them a highly characteristic appearance. Associated with such complex systems of wide and narrow tubes or occurring isolated, are larger or smaller pieces of cuticle; this may be dark and opaque but often is orange yellow and translucent, showing a definite cellular pattern. Within the cuticle and often clearly embedded in the network of fine tubes, walled spores of various sizes have been repeatedly met with. Their relation is such as to render it highly probable that they belong to the plant, but so far clear evidence of how they developed or of their organic connexion has not been obtained. This is a detail on which evidence in one direction or another is desirable.

All these features which together afford a very definite characterization of *Nematothallus* have been met with in many apparently unpromising specimens, when these are investigated on film-transfers or film-pulls. It was, however, not clear in what way the cellular pattern of the cuticle was produced, and an erroneous suggestion was advanced, rather unwillingly, that this might depend on the meshes of an underlying network of the fine tubes. A fortunate carbonized specimen, preserved of some thickness, from which microtome sections could be obtained, has now shown that there is a surface layer of cells with thick outer walls covered with cuticle. This difficult question is now satis-

factorily answered by a specimen which also shows associated-tube structure with annular thickening.

This summary account of what has so far been demonstrated in this general type of fossil may be qualified by saying that there are evidently a number of different forms under the name the most fully characterized of which has been described. In other specimens it has not been possible to demonstrate tubes of two distinct widths, or there is no proof of the presence of a cuticle over the associated tubes: these may be indications of real differences or of defective information. In any case the type with two systems of tubes, annular thickening, cuticle and associated spores has been found in the Silurian, Downtonian, Dittonian and the Carmyllie and Glencoe Beds, a rather remarkable demonstration of the abundance and wide distribution of a definite structural type.

For our present purposes the problem presented by *Prototaxites* and *Nematothallus* can be left with the remark that the structural resemblance between these two types justify the recognition of a group of anomalous plants, still imperfectly known, which may be spoken of as the Nematophytales.

### *Parka*

For figures see Don & Hickling, *Quart. J. Geol. Soc.* LXXI, Plates 54-56

*Parka decipiens* is one of the most interesting and best known of anomalous plants. Some account of it must be given here, although it is hardly necessary to do more than refer you to the excellent critical account by Don and Hickling. Though their work was done nearly thirty years ago, there is little that can be added to their account; and there is very little in it that cannot be verified by an observer on specimens that can be collected from the Carmyllie or Cairnconnan Beds of the Caledonian Lower Old Red Sandstone. *Parka* is also known from beds of generally corresponding age in England and Wales.

As it usually appears when exposed on bedding planes of the rock, *Parka* is a flat or slightly convex, circular or oval thalloid structure; ranging in size from  $\frac{1}{2}$  to 5 cm. There is no proof that it is a portion of a plant and not, as it appears, an independent organism. To naked-eye observation a good specimen shows a narrow marginal zone around the thallus; the area within this, whether the specimen is small or large, exhibits more or less closely placed, round or oval areas, which are known to mark the position of spore-masses 1-3 mm. across. These spore-mass areas or 'disks' are separated by a reticulum of sterile portions of the thallus. The structure of the whole plant is cellular. An upper epidermal layer, a lower epidermis and parenchymatous tissue between can be demonstrated in the margin and the sterile reticulum of the thallus. The compressed, flattened spore-masses are embedded in the inner parenchymatous tissue; these regions probably projected somewhat on the upper surface. The distinction of upper and lower surfaces is a reasonable assumption; there is no direct proof. The lower epidermis often becomes partially detached and separated from the upper part of the plant by a layer of the rock matrix; or it occurs, completely detached, as a radiating wrinkled structure. The flattened black disks can be macerated, the outer layers of the thallus ultimately disappearing and leaving the mass of compressed spores, yellow and translucent. With further treatment the spores may separate. They measure about  $30\mu$ , have resistant but not very thick walls, and there is no evidence, though this has been repeatedly looked for, that they developed in tetrads. There is nothing to show that they were naturally liberated from the thallus.

I have hardly anything to add to Don and Hickling's account. Less flattened specimens have been seen; there seems to have been some thickness of the inner tissue below the spore-masses. Spores of some of the spore-masses have been seen preserved in the round, not compressed or flattened; in this condition also they are not in tetrads. An alternative explanation may be suggested for one point in Don and Hickling's account. They were forced to assume that each spore-mass grew by the marginal growth. The compression



of a thallus of some thickness with the marginal spore-masses on its slope may perhaps explain the appearances they describe without this rather doubtful assumption.

*Parka* is a remarkable, unique, anomalous plant and seems to be of quite isolated systematic position. Our knowledge concerning it is considerable. There is no question that it is in essentials true; but we are not yet in possession of the whole truth even as to morphology and structure. There are, further, many things regarding development and life history of which we know nothing and of which knowledge is vital to full understanding.

Without entering into detail as to the long history of observations and opinions regarding this fossil, I may remind you of the main points. Discovered and named by Fleming in 1831, it was regarded by him and later by Hugh Miller as a compressed compound fruit or group of fruitlets. But almost at once it was alternatively interpreted as a mass of molluscan eggs and later there was general acceptance of the assumption that it was the egg-packet of *Pterygotus*; it disappeared from botany for many years. Sent to Dawson in 1890, he and Penhallow made the essential discovery that the 'eggs' were compressed masses of walled spores. But they discounted this real scientific advance by assuming that *Parka* was the sporocarp of a rhizocarp, and regarding other plant remains of the Carpyllie Beds as the vegetative organs of such plants. The validity of these views was promptly criticized by Kidston. Then the work of Don and Hickling not only cleared away these and other assumptions, but gave us a body of detailed scientific information which can be verified. It is a very instructive history.

#### *Foerstia*

For figures see *Economic Geology*, XVIII, no. 3, and *Trans. Roy. Soc. Edinb.* LIII, no. 28

Our knowledge of the fossil now known as *Foerstia furcata* (Daws.), though limited, gives information regarding form, vegetative structure and reproductive cells, sufficient to characterize a definite type of anomalous plant. It was originally described under the name *Sporocarpion* by Dawson from material obtained from Upper Devonian Shale, at Columbus, Ohio; it is known from other localities in the same rock. Dawson did not find spores in it but evidently regarded it as a sporangial structure, since he compares it with a number of undoubted sporangia. It has been reinvestigated both in America and in this country; the two investigations essentially confirm one another. The name *Foerstia* was given by White and Stadnichenko.

The fossils are small flattened black structures sometimes simple but often bifid. They are always incomplete behind. Their length is up to 5 mm. but usually less and they are 1 mm. or slightly more broad. By reflected light the cellular structure of the outer layer is evident. This layer continues round to the other side of the flattened body but internal tissue is not preserved; though doubtless present it was probably not in great amount. It is not likely that the plant was originally cylindrical; it was more probably flat, though of course now further flattened by compression. The cellular structure of the surface layer is shown more clearly when the fossil is macerated; the cells appear smaller near the tips, and along the concavity of the terminal depression. There is a thick cuticle-like layer. Maceration has further shown that below the epidermis at isolated points, often along the edges of the terminal depression but sometimes below the general surface, there were tetrads of large spores. These are resistant to full maceration and treatment with ammonia which destroys the vegetative tissue of the thallus. The spores, which measure about 200  $\mu$ , have an area by which they were in contact, with a triradiate mark. The wall is about 7  $\mu$  thick. As preserved the tetrad is flattened by compression. It may have occupied a definite cavity, but details as to this are wanting.

The tendency has been to compare this fossil, more or less tentatively, with an alga and to assume that we have before us only the persistent tips of a larger thalloid plant. This may be the right view, but it is not certain that we are justified in making such an



assumption. A possible alternative view would be that we were dealing with a small thalloid plant, growing onwards periodically and dying off behind. But we have no knowledge to justify an opinion either way.

We can only note *Foerstia* as an anomalous type and recognize that the development within the thalloid structure of isolated tetrads of large, walled spores raises interesting but unsolved questions as to the life history behind the morphological features which are all that we know.

### *Orvillea* n.g.

(Plates 22-25, figs. 1-21)

The last example of an anomalous plant to be considered is afforded by certain small fossils which occur in numbers distributed through beds of Upper Devonian Shales in Brazil. The material containing them was sent to Dawson by Orville Derby in 1883. Dawson described and named them, but the descriptions and figures do not sufficiently bring out the characteristic features of a very interesting fossil type. Further, he made a number of assumptions that must be set aside. These little fossils from Brazil required re-examination for their own sake, and the results, so far as this has been possible, are given here.

Before turning to what can be ascertained, an introductory word is necessary as to the earlier suggestions and opinions. Only main points need be noted here; reference may be made to Dawson's *Geological History of Plants* (1888), the account in which is based upon his paper of 1886 (in *Bull. Chicago Acad. Sci.* 1, 105-18). It is necessary to start by recalling the fact that certain brown, flattened spore-like bodies occur in enormous numbers in black shales of Upper Devonian age in Ontario, Ohio, Kentucky, etc. They were originally found at Kettle Point on Lake Huron by Logan. Dawson named them *Sporangites huronensis*. He at first regarded them as macrospores (or sometimes, it would seem, sporangia) of *Lepidodendron*, later as of some other group of plants. These spore-like bodies, which are still of quite undetermined nature, have characteristic thick walls traversed by fine canals which give a dotted appearance to the wall in surface view. Similar bodies, with the same characters of the thick membrane, make up the 'white coal' of Australia and Tasmania, and have been named *Tasmanites punctatus* (Newton, in *Geol. Mag. N.S.*, 2 Dec., II, 1875).

When Dawson received the Brazilian material he recognized in it flattened bodies about 3 mm. in diameter, some of which appeared to contain a number of circular bodies about the size of his *Sporangites huronensis*. This is all that his figures of the Brazilian specimens show. But Dawson regarded the latter as giving the clue as to how the bodies he had named *S. huronensis* had been borne. He held that the Brazilian specimens were 'sporocarps', each enclosing a number of 'macrospores'. Further he regarded these 'sporocarps' as closely similar to those of the existing plant *Salvinia*. He therefore named the Brazilian fossils, of which he distinguished two species, *Protosalvinia* (*Sporangites*) *brasiliensis* and *P. (S.) bilobata*. He included some spore-like bodies in the same genus, the chief being *P. huronensis* and *P. punctata*.

There is no sufficient evidence for any of these assumptions and suggested relationships. The questions need not be discussed at length, for the description of the Brazilian specimens will show their different and distinctive nature. They must be looked at by and for themselves, and therefore, retaining Dawson's specific names, are here placed in a new genus as *Orvillea brasiliensis* (Daws.) and *O. bilobata* (Daws.).

We owe to Dawson not merely the direction of attention to these fossils but the possibility of re-examining them. He sent small specimens and pieces of material to Kidston, the former being in the Kidston Collection at the Geological Survey while the small amount of working material is in my hands. Besides inspection by reflected light on the rock, it has been found possible to study the fossils by transmitted light on film preparations and as isolated by solution of the rock in hydrofluoric acid. The shales, as

Dawson pointed out, came from two localities and differ in type. A soft orange shale from Rio Curua contains specimens labelled *O. brasiliensis*, while a hard grey shale from Rio Trombetos is filled with specimens of *O. bilobata*. Most of the details ascertained have come from the study of *O. brasiliensis*, and this will be described first and most fully. The less instructive material of the other species will only require brief mention.

A piece of the orange shale containing *O. brasiliensis* is represented, enlarged two diameters, in Pl. 22, fig. 1. Small flat black fragments are abundant throughout the rock. Near the lower edge of the figure is a larger fragment, an almost complete specimen; it has the black cellular layer interrupted by a number of the small circular areas, which Dawson interpreted as macrospores. The small thallus is about 3 mm. across and the circular areas about 0.5 mm. Two small pieces of the shale in the Kidston Collection were evidently specially selected by Dawson to show, in addition to fragments, single good examples. That on no. 157 (Pl. 22, figs. 2, 3) is very like the one just described with the upper black cellular layer interrupted by a number of circular areas. The other specimen on no. 158 (Pl. 22, figs. 2, 4) is preserved in a different fashion which has only been seen in this one example. The black layer, which originally covered the upper surface, has been lost, save for a piece near the margin and below on the left. The circular areas appear as depressions in the matrix as if their contents had originally been preserved in the solid. The only indication of a layer below is obscure dark material at the bottom of some of the depressions. In both these specimens (nos. 157, 158), however, there are clear traces of what will be shown to be a middle layer of the thallus in the form of dark walls separating polygonal areas or chambers, which measure 150–200  $\mu$ . The flat specimens such as those in Pl. 22, figs. 1, 3, are the usual type of preservation. All three specimens indicate a flat thalloid structure 3 mm. or slightly more in diameter.

The largest and most complete fragment, removed on a film-pull, mounted in canada balsam and viewed by transmitted light, is represented at a low magnification in Pl. 25, fig. 5. It includes part of the curved margin of a flat thalloid body that must have been about 3 mm. in diameter: the complete thickness is preserved. There is a superficial layer of small-celled tissue on the surface turned to the observer. At the true margin it was clear that this layer continued round the edge and covered the other side of the flat expansion, which thus has an upper and lower epidermis. This layer has a thick cracked cuticle that was best seen in optical section as it bent round the margin at the extreme left. Between the upper and lower layer of small-celled tissue there intervenes a single layer of larger structures 100–200  $\mu$  wide in this specimen. The question whether these are to be regarded as large 'cells' or as 'cavities' separated by cellular partitions has proved to be a difficult one and will be discussed later. Their outlines can be seen through the upper small-celled layer and more clearly at places where this has disappeared; in the latter case deeper focusing may show the small-celled layer on the other side. The general vegetative structure is evident in this and other specimens; difficulties arise when the attempt is made to be more precise as to details. A last feature shown in Pl. 22, fig. 5, is that there are three or four circular structures, approaching 400  $\mu$  in diameter, with dark opaque boundaries. Their position between the upper and lower small-celled layers is certain, as well as their much greater size than the vegetative 'cavities', but their nature as the reproductive structures will only become clear in better examples. In this specimen they are rather small and some of them may be immature. One of them, on the extreme right, shows, rather obscurely, three walls meeting in the centre, which probably depend on the presence of a tetrad of spores. The interest of this particular piece of thallus is that it indicates the size, that it shows the complete set of structures making up the vegetative region, and that it also shows the position of two or three of the circular reproductive regions. Most of these points are better seen in other fragments but not in such complete association.

While some fragments like that just considered have the complete thickness of the flat thalloid structure, many only show a small-celled layer or such a layer with a reti-

cum of the boundaries of the internal 'chambers'. Evidently the thallus as it decayed tended to break through its middle layer, separating the upper and lower epidermal layers. This is probably why the specimens in the Kidston Collection (Pl. 22, figs. 2-4) show one small-celled layer and the large polygonal areas or chambers below this, but no sign of the lower small-celled layer.

A few features of the vegetative structure are shown at somewhat higher magnifications on Pl. 23. Pl. 23, fig. 8, shows a region from the left-hand side of the specimen in Pl. 22, fig. 5, with an opaque part of the thallus covered over with epidermis and cuticle on the left and farther to the right the inner chambers more or less exposed with the small-celled layer of the lower surface out of focus beyond. Pl. 23, figs. 9, 10, from other fragments show the outlines of the inner chambers completely covered by the outer small-celled layer. It will be seen that the size of the small cells is about  $50\mu$  or less, and that of the inner chambers about  $200-300\mu$ . Pl. 23, fig. 11, also from a separate fragment, shows internal chambers partly covered by the small-celled layer and in other cases seen more clearly where this has disappeared.

Such examples of the vegetative structure could be multiplied. The difficulty has been and still is to find a region that will show decisively the nature of the partition walls of the internal 'chambers'. It seemed possible to regard the first examples that were studied as cell-walls bounding an internal layer of large cells. But it has become increasingly difficult to hold this view, and the appearance in some cases is suggestive of a cellular partition and not of a cell-wall. For the present the question must be left an open one. It is very desirable to become clear as to this point in the construction of the vegetative region. For the way in which the circular reproductive structures are scattered in the thallus leaves little doubt of each corresponding in position to one 'chamber' or 'cell'. Thus the true nature of these has a very direct bearing on the interpretation of the circular structures.

These measure about  $\frac{1}{2}$  mm. usually, though smaller and slightly larger examples are met with. Their distribution was seen in the piece of thallus in Pl. 22, fig. 5. A number of fragments have shown their detailed appearance very well, up to a point beyond which it is difficult to get. This will be evident from Pl. 22, fig. 6 and Pl. 24, figs. 12-14. It is usually difficult to make out the structure of the dark boundary of the circular area, but it seems clear that it extended vertically between the lower and upper small-celled layers of the thallus. These have been traced both below and above circular cavities. The small-celled layer below the cavity is flat or tends to be concave, i.e. pressed upwards. On the other hand, it is well demonstrated that the small-celled layer above the circular cavity is convex and rises above the general surface, even in the flattened condition of the whole specimen (Pl. 24, fig. 14; Pl. 25, fig. 18). If this covering were removed, naturally or otherwise, the appearance of circular interruptions of the black cellular layer seen in specimens on the rock would result.

The striking fact about the circular chambers is that each contains a tetrad of large spores. This is demonstrated by a number of good specimens, several of which are figured (Pl. 22, fig. 6; Pl. 24, figs. 12-14). The spores are visible more or less clearly, sometimes covered by the basal small-celled layer, or if viewed from above by the convex upper layer; sometimes exposed in the cavity with the covering layer gone. Imperfect tetrads partially freed from the surrounding thallus occur on the film-pulls (Pl. 24, fig. 15). A completely isolated tetrad dissolved out from the shale is shown in Pl. 24, fig. 17. There are clear indications of a contact area on each spore with a tri-radiate mark in several examples, though no view of an isolated spore from this face has been obtained. Each spore measures about  $200\mu$  along the diameter that lies tangentially in the tetrad, which seems slightly greater than the radial measurement. The spore-wall is firm but not specially thick (Pl. 24, fig. 16). It need hardly be said that it has none of the characters of the wall of *Sporangites huronensis*.

After the tetrads of spores had been found in the translucent preparations, a careful

scrutiny was made of all specimens on the rock which showed the circular areas interrupting the black layer. In one case several of these areas close together and belonging to one imperfect thallus had retained several of the spores in position and could be photographed by reflected light (Pl. 22, fig. 7). Another region of this thallus shows the chambers of the vegetative region when the black upper epidermis had disappeared.

All the associated details so far described can be taken as characteristic of one species, *Orvillea brasiliensis*. The cells of the epidermal layers in this give the impression of being small compared with those of some of the other cellular fragments in the same shale. It is not easy to be precise as to measurement but a fair statement is that they are round about  $50\mu$ . Other fragments of similar tissue in the rock have obviously larger cells, some being round about  $75\mu$  or even larger. Many of them show nothing but the single layer of cells but some have a clear pattern of 'chambers'. An example is given in Pl. 25, fig. 19; the chambers on this ranged from  $360\mu$  to nearly 1 mm. in maximum width. The size attained is against interpreting them as cells, and in addition the partitions have a suggestive appearance of being cell-layers. Such fragments of tissue are evidently derived from plants of the same general nature as the better known *O. brasiliensis*, but it is useless to go into the question of specific forms on such limited fragmentary material.

In the specimens in the hard shale from Rio Trombetos, that, following Dawson's specific distinction, can be referred to as *O. bilobata*, the cells of the single epidermal layer, which is all that is preserved of the structure, are also relatively large. A piece of this layer is photographed in Pl. 25, fig. 21; many of the cells measure  $160 \times 80\mu$ . The material available of this species was a small piece of the rock full of the flat thalloid bodies which were well preserved as to their external form and outline, but not as to their structure. A portion of the best surface of the hand-specimen is represented, magnified 2 diameters, in Pl. 25, fig. 20. It shows numerous convex or concave impressions, circular or oval, and completely, or more usually incompletely, covered with the single layer of black cellular epidermis which is all that persists of the plant. The convex specimens are looked at from their upper side and in some cases the black layer is raised slightly over circular areas. In others the coverings over the circular areas have been removed or otherwise disappeared and the black layer is interrupted by a number of circular areas which do not overlap. In the light of our knowledge of similar specimens of *O. brasiliensis* it seems safe to assume that a tetrad of spores was developed in each of these circular structures. But there is no direct evidence of this nor of the further structure of the thallus. The occasional bilobed appearance, that suggested the specific name, seems to be merely the result of unequal exposure of bent individuals of the usual shape.

On reviewing the preceding account it will be seen that we have a considerable, though in some respects seriously imperfect, knowledge of *Orvillea*. We appear to be dealing with small independent thalloid plants with a characteristic vegetative structure and with tetrads of large spores as reproductive cells. These tetrads are found in definite circular chambers, which appear to correspond to those of the vegetative part of the thallus. If these chambers, as seems almost forced upon us, are not large cells but are spaces bounded by cellular partitions, the formation of the tetrad within them is, on our present knowledge, unexplained. It is necessary to recognize this but useless to discuss it until some further facts are available. But, merely taking the facts we know, *Orvillea* seems to be naturally regarded as an isolated anomalous type of great interest. It is most closely comparable to *Foerstia* as regards its epidermal tissue and the production internally of tetrads of spores with firm cell walls. As with that plant, questions are raised as to the development and life-history underlying the morphological features that are definitely known.

## CONCLUDING REMARKS

In the first part of this lecture we followed the history of *Pachytheca* and recognized how knowledge of this little plant has resulted from its progressive investigation. It seems to be clearly referable to the Algae, taking this group in a comprehensive sense as including Blue Green Algae, but no type closely corresponding to it is known either among existing or extinct plants. This morphological isolation is rather striking, for it is unlike what is found to hold for all the other early algae that are at all adequately known as regards their structure. These have proved, as will be remembered without citing examples, to be referable to particular algal groups such as the Dasycladaceae, Codiaceae, Corallinaceae, Characeae; or at least to exhibit definite characters justifying comparison with such groups.

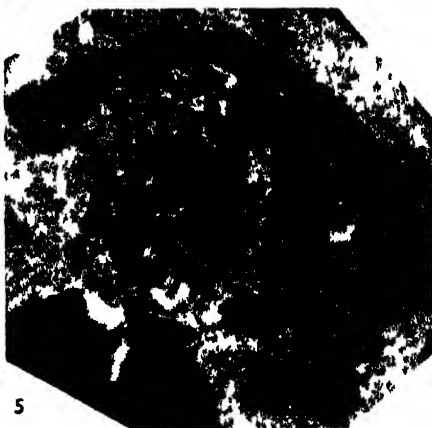
From *Pachytheca* we were led to consider a number of still more isolated early plants, so isolated that it is difficult or impossible to place them in any of the great groups of plants. These have been spoken of as anomalous. They are of a variety of different types and present interesting, and at present insoluble, problems to the morphologist and systematist. It looks as if botany may prove richer in such anomalous forms than zoology. Already the body of information about them is considerable. They are worth very careful study and must not be passed over as palaeobotanical curiosities.

Evidently no general conclusions are possible from a survey of such forms. The essential fact that emerges is their systematic isolation. All that can be done to end and, so far as possible, to round off this lecture is to make a few remarks suggested by the history of investigation and opinion on these plants.

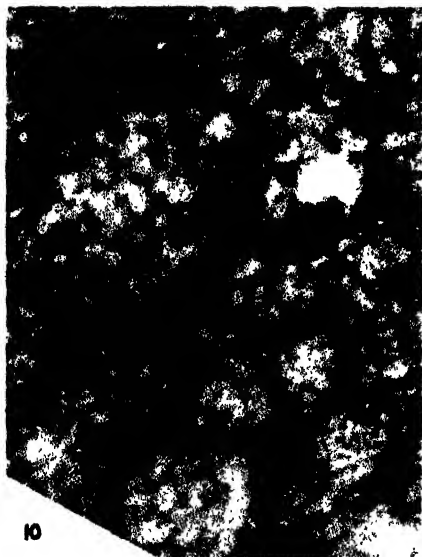
The student of fossil plants labours under some disadvantages as compared with the palaeontologist, but has compensating advantages. Fossil plants are less useful to the stratigraphical geologist than the animals. I have been reproached for this by geological friends, and Hooker's essay on the Carboniferous Flora was, in part, a defence against a similar attitude. But the botanist gains by having his time-table determined, without its being based on the plant-remains which are his material. He has a further great advantage in having his knowledge of the external form of fossil plants supplemented by more or less structural information regarding them. This may be wonderfully detailed, including gross anatomy and histology and sometimes even cell-structure with the nuclei preserved. But even apparently poor incrustations may yield significant facts about internal structure. The result is to provide much more valuable data for comparative morphology than if we knew only the external form of more or less connected or complete portions of plants; fortunately these often include the reproductive organs. Most of the plants that we have been considering are examples of the value of combining knowledge of form and structure. It is desirable to ascertain all details of both that can be demonstrated. There are of course dangers of making assumptions in the study of structure as well as in observing the form of the fossil on the rock. But in several of the cases dealt with here it has been careful study of structure that has put work, that had gone wrong owing to misleading views based on external form, again upon right lines.

We are always studying fossils, not directly observing a plant. The attempt has to be made to get at a reliable conception of the plant through the fossils, with all the difficulties that various types of preservation introduce into the work. The discovery and thorough working out of particular instructive specimens, not by any means necessarily good museum specimens, is especially helpful. In this connexion it is perhaps worth while emphasizing the importance of carefully preserving not only type specimens but authenticating specimens and preparations that demonstrate detailed facts.

It is natural and tempting to go a little beyond the facts observed, to connect features in order to obtain a better and more satisfying picture. To some extent this is probably inescapable but it is necessary to guard against its dangers. We can all see points regarding the plants we have been looking at on which more information and insight is













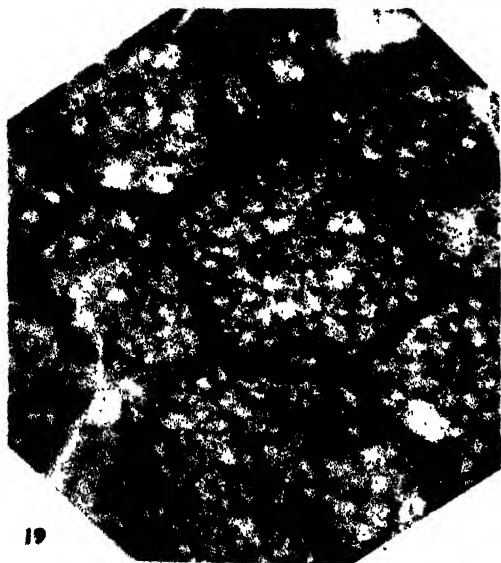




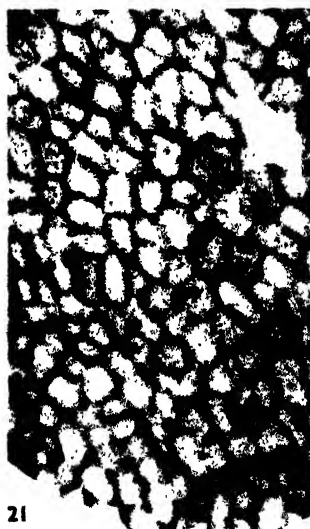
18



20



19



21

18. ORVILLEA BRASILIENSIS. 19. ORVILLEA SP.  
20. 21. ORVILLEA BILOBATA



highly desirable. They concern construction, habitat and especially the unknown life-history behind the morphology of the reproductive structures. Such questions are well worth keeping in mind as directing enquiries in the field or laboratory and stimulating the search for evidence. Otherwise speculation upon them usually proves rather fruitless. We can also all speculate as to the systematic position and evolutionary bearings of such plants. This again is quite legitimate and perhaps desirable, but again is of little use, save as suggesting points for investigation. On one thing I feel clear, that the working fossil botanist is well to keep clear of accepting any such speculations. His job is to get the best objective account of the extinct plants that he can; gaps in his knowledge are to be pointed out and emphasized. The general botanist can use the information thus provided, but if he goes beyond ascertained fact he does so at his own peril.

In beginning to observe an existing plant or a small portion of one a systematic approach is natural. We almost at once place it more or less closely in its larger or smaller group in the natural system; we feel sure that it is a liverwort, an alga, a conifer, etc. This at once gives a background to our further observations which cease to be purely objective. Usually, or at least very often, this is all to the good; occasionally it is misleading. But it is much more dangerous when we are starting to observe a fossil. It may then not merely modify the objective attitude which is necessary but may be seriously misleading. The history of opinion on plant after plant of those with which we have been concerned provides warning of the dangers of making assumptions as to morphological nature and systematic position. The result has often been to illustrate and justify one of Hooker's judgements on fossil botany as 'the most unreliable of sciences'.

There is, however, a large credit side to critical work, even on such obscure fossils, especially when external form has been supplemented by structural details. The contribution of fact which the study of the fossil plants, of all geological periods from the Tertiary back to the Devonian and Silurian, has made to comparative morphology and to the natural system does not need to be stressed. On this more favourable aspect of palaeobotany I may end with another quotation from a letter by Sir Joseph Hooker. It was written in 1847, nearly a hundred years ago; but the fossil botanist to-day could hardly wish for a better charter. 'I am no Geologist; my work is fossil botany; as legitimately a branch of *Botany* as is *Muscology*; fossil plants, though imperfect, are still *pure plants*; and, though dead as species, they form and show links between existing forms, upon which they throw a marvellous light.'

## EXPLANATION OF THE PLATES

### PLATE 22

#### *Orvillea brasiliensis*

- Fig. 1. Surface of piece of shale from Rio Curua with fragments of *Orvillea brasiliensis* and, near the lower edge, a larger piece with circular reproductive chambers.  $\times 2$ .  
 Fig. 2. Specimens in the Kidston Collection selected by Dawson; both nos. 157 and 158 have examples showing the complete outline with circular reproductive chambers.  $\times 2$ .  
 Fig. 3. The example from no. 157.  $\times 10$ .  
 Fig. 4. The example from no. 158.  $\times 10$ .  
 Fig. 5. Portion of a thallus removed on a film-pull. It includes a part of the true margin and shows the internal chambers in the vegetative region covered above and below with the small-celled epidermal layers. Two or three circular reproductive chambers can also be distinguished.  $\times 25$ .  
 Fig. 6. A circular reproductive chamber from another fragment showing the tetrad of spores within.  $\times 100$ .  
 Fig. 7. Incomplete specimen of the thallus on the shale, viewed by reflected light, showing circular chambers in several of which two or three of the spores remain.  $\times 10$ .

## PLATE 23

*Orvillea brasiliensis*

Fig. 8. Portion of the specimen in fig. 5; the dark region to the left is opaque owing to the complete epidermis with cuticle, but further to the right this is partially removed and the internal chambers are shown.  $\times 100$ .

Fig. 9. Portion of another fragment showing the chambers covered by the small-celled upper epidermal layer.  $\times 100$ .

Fig. 10. Piece of another fragment showing the small-celled epidermis viewed from the inside with the reticulum of the boundaries of the internal chambers.  $\times 100$ .

Fig. 11. Piece of another fragment showing above and to the right the epidermis and below, where this has disappeared, the internal chambers.  $\times 100$ .

## PLATE 24

*Orvillea brasiliensis*

Fig. 12. Piece of thallus showing the small-celled tissue and two circular chambers seen from above; that on the left with a tetrad of spores while that on the right only shows small portions of the walls of the four spores.  $\times 50$ .

Fig. 13. Fragment of thallus with two rather small circular chambers seen from below; the tetrad in each is covered by the lower epidermal layer.  $\times 50$ .

Fig. 14. Fragment of thallus with two circular chambers and portions of two others. The chambers contain tetrads that are covered by the convex extension of the upper epidermis, the cellular structure is well seen over the general surface.  $\times 50$ .

Fig. 15. Broken tetrad on a film-pull showing three of the spores; and on the right a portion of the wall of the chamber; the spore on the left has indications of the triradiate marking.  $\times 100$ .

Fig. 16. Three spores of a tetrad from a broken chamber at the edge of a fragment; the spores show the wall in section.  $\times 100$ .

Fig. 17. Tetrad isolated by solution from the rock.  $\times 100$ .

## PLATE 25

Fig. 18. *Orvillea brasiliensis*. Fig. 19. *Orvillea* sp. Figs. 20, 21. *O. bilobata*.

Fig. 18. Fragment of *O. brasiliensis* showing portions of the convex upper covering walls of two circular chambers.  $\times 50$ .

Fig. 19. *Orvillea* sp. Piece of epidermis with the boundary walls of the internal chambers. The size of the epidermal cells and of the chambers is much greater than in the case of *O. brasiliensis*.  $\times 50$ .

Fig. 20. Piece of shale from Rio Trombetos showing the outlines of numerous thalli of *O. bilobata* and in some examples remains of the black upper epidermis and the interruptions in this due to circular reproductive chambers.  $\times 2$ .

Fig. 21. Portion of the upper epidermis of *O. bilobata*, the cells are much larger than in *O. brasiliensis*  $\times 50$ .

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